The Grazier's Guide to Pastures

Sowing and managing profitable pastures in the Central and Southern Tablelands, Monaro and Upper South West Slopes of New South Wales

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NSW Agriculture

This guide to pastures in the Central and Southern Tablelands, Monaro and Upper South West Slopes of NSW is based on research and the experience of farmers and district advisory officers. This publication is intended to provide producers with the most important aspects of pasture work. References for further information on various topics are listed at the end of most chapters.

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Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (June 2000). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up-to-date and to check currency of the information with the appropriate officer of New South Wales Department of Agriculture or the user's independent adviser.

Pasture Improvement

Pasture improvement may be associated with an increase in the incidence of certain livestock health disorders. Livestock and production losses from some disorders are possible. Management may need to be modified to minimise risk. Consult your veterinarian or adviser when planning pasture improvement.

The Native Vegetation Act (1997) restricts some pasture improvement practices where existing pasture contains native species. Inquire through your office of the Department of Land and Water Conservation for further details.

Always Read The Label

Users of agricultural (or veterinary) chemical products must always read the label and any Permit, before using the product, and strictly comply with the directions on the label and the conditions of any Permit. Users are not absolved from compliance with the directions on the label or the conditions of the permit by reason of any statement made or omitted to be made in this publication.

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Introduced Grasses

Cocksfoot – Photo: D.Eddy

Phalaris – Photo: D.Eddy

Perennial Rygrass

Fescue – Photo: M. Keys

Native Grasses

Danthonia – Photo: M. Mitchell

Microlaena – Photo: M. Mitchell

Red Grass – Photo: M. Mitchell

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Legumes

Balansa Clover – Photo: M. Lattimore

Sub Clover – Photo: M. Lattimore

White Clover – Photo: M. Lattimore

Lucerne – Photo: M. Lattimore

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1. INTRODUCTION

When pastures are well matched to soils, aspect, topography, climate and livestock enterprise they have the potential to support high levels of livestock production, provided they are well managed. Well managed perennial pastures provide good ground cover which, in turn, reduce various forms of soil degradation (soil acidification, rising water tables and dryland salinisation). They can also limit nutrient run-off into streams and weed invasion, increase beneficial soil micro-organisms and improve soil structure, pasture composition and fertility.

Perennial pastures are the basis of both sustainable and efficient livestock production in this region. The aim of this booklet is to provide information to help producers select the right pasture development options and suitable species for their locality, enterprise and paddock based on whole farm strategies.

The whole farm approach may include identifying landscapes where certain pastures or even grazing are not suited. It includes broad consideration of livestock requirements, not just for fodder but also for factors such as shelter. Exposure, for instance, can cause serious lamb losses during winter and in hot, windy weather it also reduces pasture production through increased evaporation.

Productive and persistent perennial grass based pastures are essential for sustainable land use. With adequate nutrition such pastures use water more efficiently producing up to three times more feed per millimetre of rain than nutrient deficient, unfertilised pastures. They tolerate drought better and remain green longer in late spring, respond more quickly to rain especially in autumn and have more legume and overall higher feed quality. These attributes provide the potential for high profitability.

While overall soil fertility determines the level of production, a high level of management skill is required to sustain optimum production from pastures whether they comprise native perennials with introduced legumes or fully introduced sown species.

2. THE AREA

This publication covers the Central and Southern Tablelands, Monaro and Upper South West Slopes of NSW (see map). This area will henceforth be referred to as 'the region'.

Most of the region is at least 500 m above sea level, rising to over 1000 m in many areas. It therefore has relatively cool summers. Rainfall is fairly evenly spread throughout the year. The topography is mainly undulating to hilly and erodible in nature so is best suited to grazing enterprises based on perennial pastures.

3. CLIMATE OF THE REGION

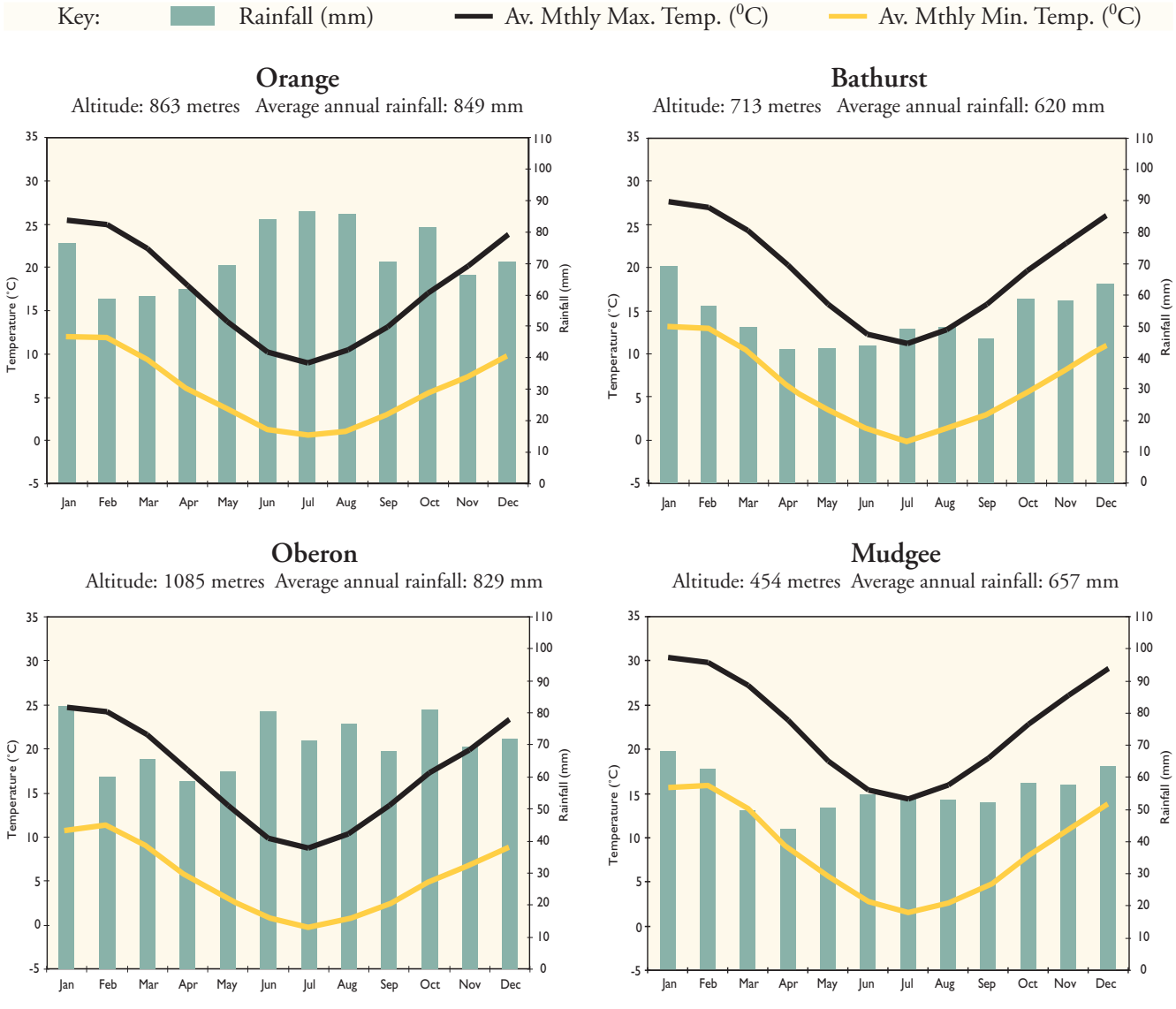
Throughout the region altitude has a marked effect on both rainfall and temperature. In summer, evaporation often exceeds rainfall and pasture growth is limited by moisture. In winter, rainfall normally exceeds evaporation, but pasture growth is restricted by cold temperatures and in some cases by waterlogging.

All areas are prone to severe frosts. Higher areas are cooler, have high rainfall, severe winters, occasional snowfalls and milder summers. Lower areas are drier in summer due to higher temperatures and greater evaporation.

In the main, long-term average monthly rainfall shows a relatively even distribution throughout the year. However, between and within year variation is large. Autumn break rains tend to be particularly unreliable.

Central Tablelands: Annual rainfall in the central tablelands varies from around 600 mm to 900 mm while the frost free period varies from 150 to 240 days a year depending on altitude. **Fig 3.1** provides data from four central tablelands towns covering the climatic range.

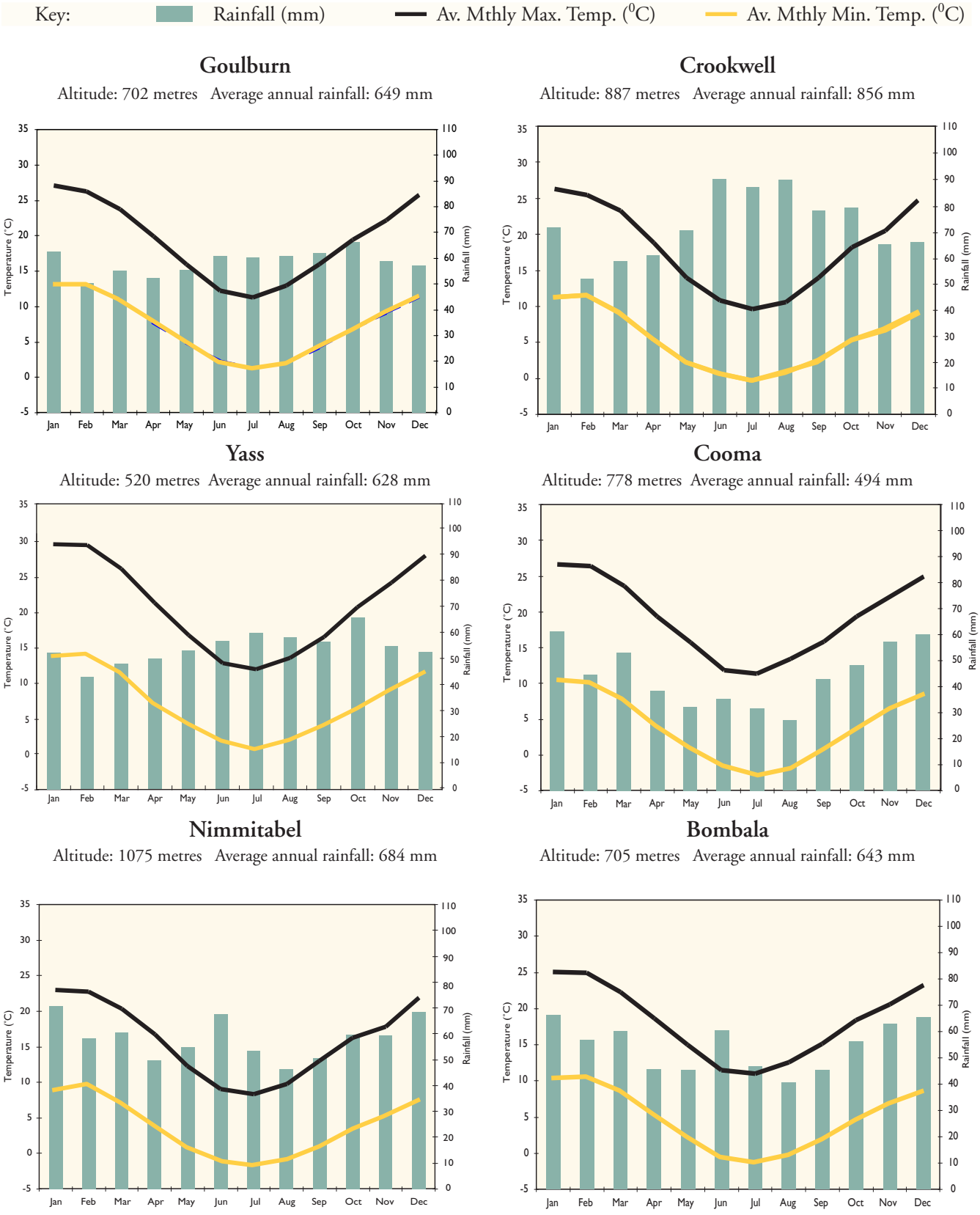
Fig 3.1 Temperature and rainfall distribution across the Central Tablelands[1]



[1] *Data extracted from the MetAccess weather decision support system, using all historical data available.*

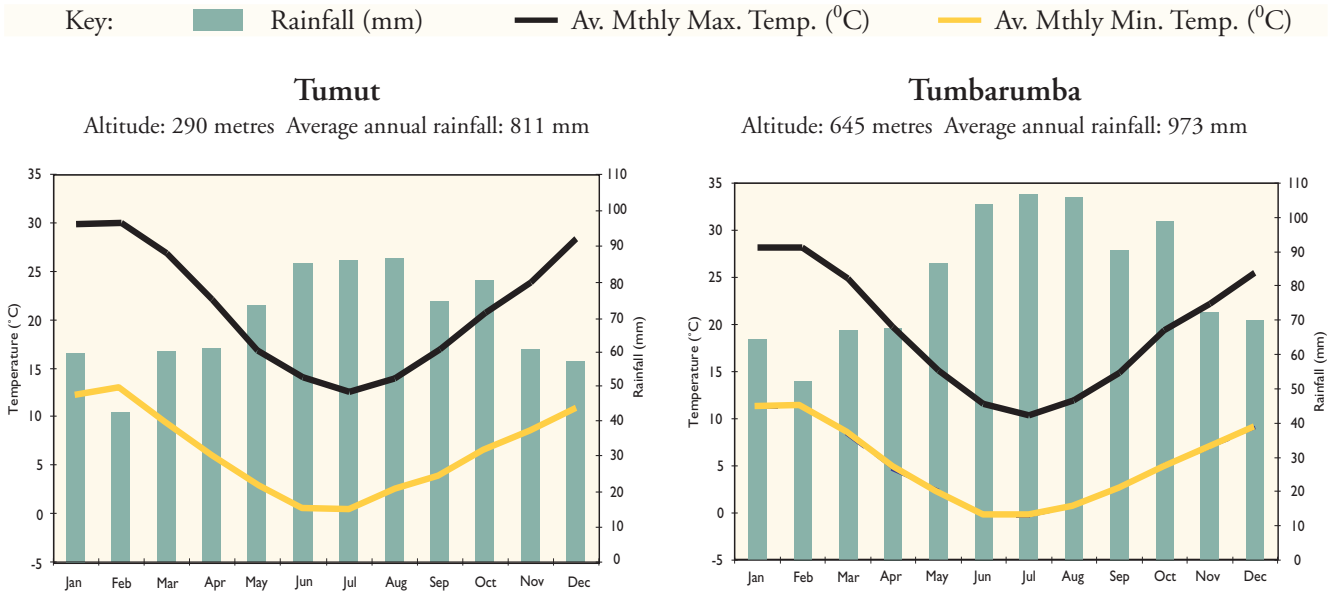
Southern Tablelands, Monaro & Upper South West Slopes: Annual rainfall in this diverse region varies from below 500 mm to 1200 mm and frost free periods vary from 140 to 260 days a year depending on altitude. **Fig 3.2** provides data from eight towns within this area. The Upper South West Slopes has the most pronounced Mediterranean climate (wet winter; dry summer pattern).

Fig 3.2 (a) Temperature and rainfall distribution at six Southern Tablelands and Monaro towns[1]



[1] *Data extracted from the MetAccess weather decision support system, using all historical data available.*

Fig 3.2 (b) Temperature and rainfall distribution at two South West Slope towns[1]



Implications of Climate for Pasture Growth

The interaction of temperature, effective rainfall and radiation directly influences pasture growth. Effective rainfall is often the most limiting factor to pasture growth for most of the year while in winter, low temperatures are the most limiting factor, especially at high altitude.

a. Temperature

Temperatures between 12°C and 30°C favour plant growth by most temperate species. Pasture growth increases with warmer temperatures, provided there is adequate moisture. However, once temperature drops below 8°C, pasture growth is minimal.

The effect of frost depends on the pasture species. Frost damage is most severe on older leaves, even in more frost tolerant species, in all cases reducing feed quality. Frost sensitive species such as Kangaroo grass *(Themeda)* and red grass *(Bothriochloa)* stop growing at warmer winter temperatures than the more frost tolerant, winter green species like microlaena, wallaby grass *(Austrodanthonia)*, phalaris and ryegrass. Thus frost sensitive species do not provide any feed for 4-6 months in this region.

b. Rainfall

Actual rainfall and *effective* rainfall in a period are not the same and can have vastly different effects on pasture growth. For example, rain falling in summer when evaporation rates are high will not be as effective as the same amount of rain falling mid autumn when evaporation rates are lower. Similarly, a high proportion of very intense summer storm rain becomes run-off, doesn't enter the soil and is less effective than the same amount of gentle rain.

The response of pastures to summer moisture varies with the species. Species that respond to summer rainfall include fescue, lucerne, microlaena and red grass. By comparison, phalaris has a heat dormancy mechanism and does not respond as well to summer rainfall while annuals are only present as seed over the summer months.

c. Radiation (Sunlight)

Pasture growth increases as radiation increases and radiation is directly related to day-length and cloud cover. During winter, cloudy weather can severely limit the already minimal winter pasture growth.

Rainfall Pattern and Variability

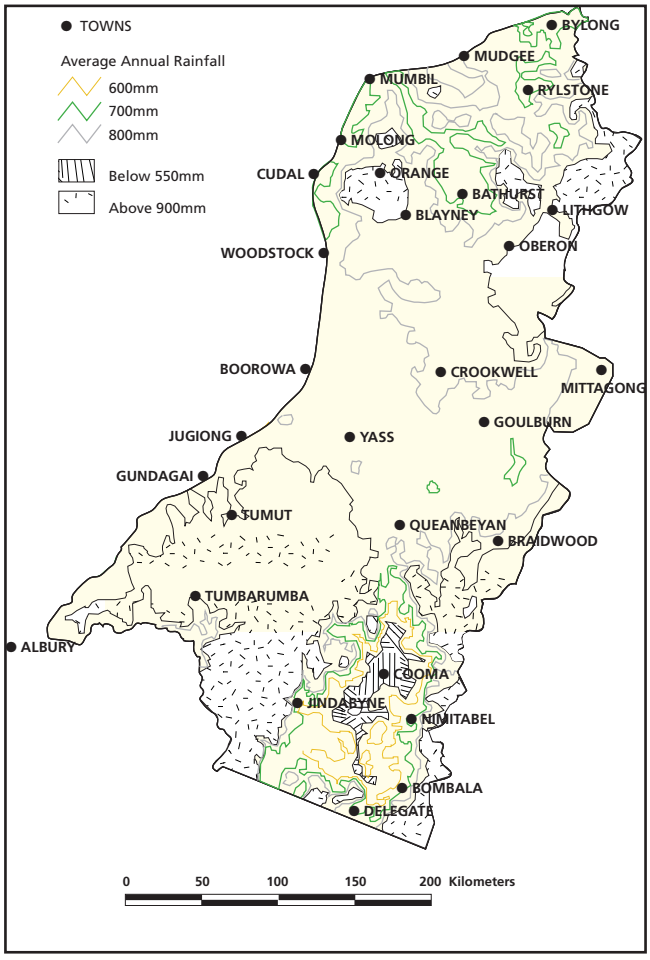
The pattern of rainfall throughout the year is a key determinant of plant growth. If adequate rain falls at critical times during the year it can make the difference between a good season and a bad one, irrespective of total annual rainfall. Four situations which highlight this are:

- A dry autumn may produce a winter feed drought but a very wet winter may also produce little feed due to cold temperatures and waterlogging that limit pasture growth.
- Similarly, high intensity summer storms are often less effective due to high evaporation and high run-off.
- Good summer rain often allows annual species, particularly sub clover, to germinate. However this often leads to a ***false break*** with seedlings often unable to survive a subsequent warm, dry autumn.
- Where no significant rain has fallen in autumn, rain falling in June is called a ***late break***. In this situation cold temperatures allow very little growth to occur

[1] *Data extracted from the MetAccess weather decision support system, using all historical data available.*

before winter sets in and so there is a green, winter drought. Conversely, a good ***early break*** in March or April can provide ample feed over winter, even though the actual winter rainfall might be low.

Fig 3.3 Average annual rainfall across the region



Annual and Seasonal Rainfall

Fig 3.3 shows the general trend of average annual rainfall across the region. Rainfall can vary considerably in any particular season and thus average monthly rainfall figures are only suitable as a guide.

Variability

The variability of rainfall from year to year for a location is important and can be evaluated by comparing the long-term averages with the range of values that occur over a period of years.

Throughout the region rainfall is extremely variable between years. **Table 3.1** shows how rainfall during summer (Dec–Feb) varies at Yass. The figures show that while the long-term averages are reasonably high, there are rarely two successive months with good above average summer falls. Therefore summer pasture production is quite unreliable.

A more precise climatic indicator is the probability of getting a certain amount of rain at a particular time based on historical rainfall records.

Computer software packages are available which help users better understand climate trends. An example is the CSIRO developed decision support system, MetAccess available from Horizon Technology, phone (02) 9805 1941.

Table 3.1 Monthly Rainfall Variability During Summer at Yass (1898-1997)

	Dec (mm)	Jan (mm)	Feb (mm)
100 year mean	**52.3**	**52.1**	**42.8**
1996/7	71.6	23.8	17.0
1997/8	21.1	37.5	34.6
1998/9	19.7	60.2	8.4

Points to Remember

- Annual and seasonal rainfall variability is the key climatic factor influencing the amount of pasture grown.
- Temperature is usually the most limiting climatic factor influencing pasture growth during winter, especially at higher altitudes.

Further Information

NSW Agriculture publications:

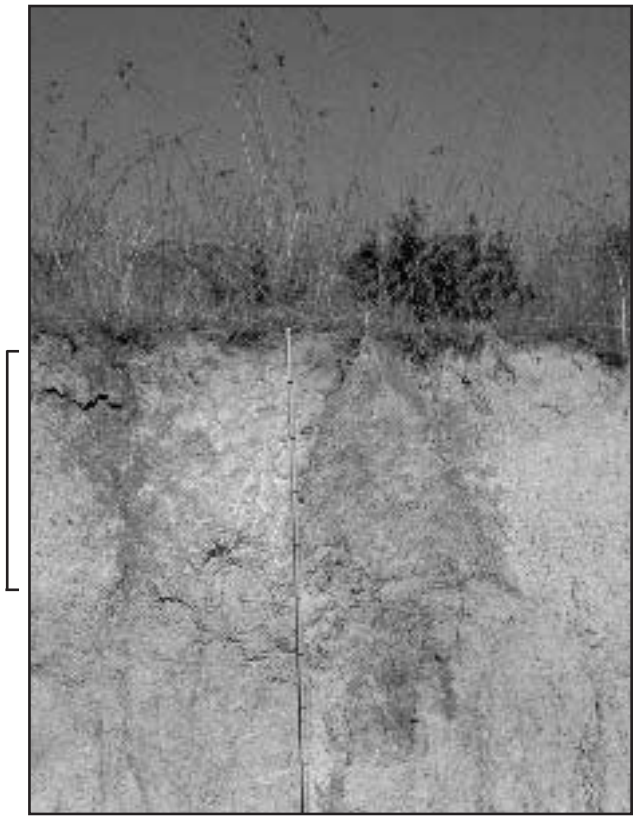
Agnote 1/ET *What drives NSW weather?*
Agnote 2/ET *The southern oscillation index and southern Australia.*
Agnote 3/ET *Guidelines for drought management.*
Agnote 4/ET *Where does the wind come from?*
Agnote 5/ET *Air masses influencing Australian weather.*
Agnote 6/ET *Understanding the statistics used to describe your rainfall.*
Agnote 7/ET *Understanding the weather map.*
Agnote 8/ET *El Nino and the southern oscillation index.*

4. SOILS OF THE REGION

Extensive folding during the formation of the Great Dividing Range, the main geological feature of this entire area, has meant that rock, soil type and fertility changes vary widely over quite small distances. Parent rock materials not only change with horizontal distance but can also change with vertical height as different layers of parent rock material are exposed.

Differing parent materials such as sandstone, slate/shale, granite or basalt combined with other factors such as geological age, climate, topography and land use, have produced a range of soils which vary in fertility, acidity and many other aspects.

Tablelands soils are generally acidic, of low to moderate soil fertility and phosphorus, sulphur and molybdenum deficiencies are common.



A typical tableland soil-an extensive bleached structureless A2 layer with yellow clay subsoil below.

Soil fertility encompasses not only the levels of important plant nutrients such as nitrogen or phosphorus, but also the soil cation exchange capacity (CEC). This is the capacity of the soil to hold and exchange positively charged minerals (cations) such as calcium, magnesium, potassium, sodium and aluminium and is dependent on the type and amount of clay and organic matter present. The CEC and the proportion or ratios of its cations can affect soil structural stability, nutrient availability, soil pH and fertiliser response. Low fertility soils generally have a low CEC i.e. < 2.5

Soil Indicators

Physical features of the tablelands landscape such as slope, aspect, soil depth and amount of rock can limit land use and development potential of all soil types. However, there are some natural landscape features that can broadly provide an indication of soil fertility.

(i) Vegetation

Natural vegetation such as tree types are useful indicators. For example where yellow box *(Eucalyptus meliodora)* or white box *(E. albens)* are the dominant trees, there will be few problems in establishing introduced pastures. Woollybutt *(E. longifolia)*, black sallee *(E. stellulata)*, or stringybark *(E. macrorhyncha)* generally indicate soils are more shallow and acidic with slightly less productive potential. Peppermints *(E. radiata, E. dives)*, ironbark *(E. sideroxylon)*, scribbly gum *(E. rossi)* and she-oak *(Casaurina glauca)* usually grow on infertile, acidic soils.

(ii) Rock Type

Soils may also be categorised by the parent material from which they are formed and there are five broad categories based on rock type which provide a guide to potential productivity.

- **Sandstone:** Usually found along the eastern edge of the tablelands. These soil types are generally of low fertility i.e. they have a very low CEC and are deficient in a range of nutrients, often including potassium. Sandstone soils have very little clay, are sandy to depth and so have low water and nutrient holding capacities.
- **Slate/Shale:** Slate/shale soils vary widely in their physical properties, fertility, acidity and depth. These fine grained sedimentary soils often have a hard setting loamy surface and a clay subsoil which waterlogs quickly in low areas or wet years. Cultivation under dry conditions destroys soil structure and readily leads to compaction and low water infiltration.

Slate/shale soils have low to moderate fertility, depending on the parent rock. Deficiencies of phosphorus, sulphur and molybdenum are common and most of these soils are acidic and some very acidic. Some slate/shale soils are very stony with parallel ridges of rock protruding through the surface at close and regular intervals limiting or preventing cultivation.

- **Basalt:** Basalt derived soils generally have good natural fertility i.e. a high CEC and good levels of nutrients, although sulphur is sometimes deficient. Basalt soils are usually red, black or chocolate coloured with a high clay content that increases with depth.

  Basalt soils are suitable for most agricultural production, although some may be rocky, limiting or preventing cultivation.

  Caution: many red soils are incorrectly called basalt soils, the red colour only indicating a high iron or aluminium content and not that the soil is basaltic.
- **Granite:** Widespread throughout the region, granite derived soils vary from fine to coarse depending on the type of granite. They are typified by fine to coarse sandy surface soils and generally low water holding capacity. Granites usually have clay in the subsoil, which is often dispersible i.e. becomes boggy in wet winters.

  Soil fertility varies from low to medium, with the coarser white or grey granites being of lower fertility than pink granites. Granite soils are quite erosion prone due to the combination of their sandy surface and dispersible subsoils.
- **Alluvial:** These soils are found on the flood plains of rivers and creeks. They have little profile development due to their recent geological formation. The alluvials tend to be deep (often exceeding 2 m) and can range in texture from silty loams to clay loams. They are usually fertile and can be acid to neutral in pH. Alluvial soils on the tablelands are often used intensively for cropping, pasture or lucerne hay.

Table 4.1. Characteristics of Soils Based on Rock Type

Rock Type	Characteristic
Sandstone	Low fertility, highly acidic Low water holding capacity Erodible
Slate/Shale	Low to moderate fertility Hard setting surface Mostly acid and shallow
Basalt	High natural fertility Can be rocky and non arable Often sulphur deficient
Granite	Low to moderate fertility Erosion prone Low water holding capacity Respond well to fertilisers
Alluvial	Good natural fertility Usually good soil depth Often quite small areas Flood/stream bank erosion risks

Soil Testing: While these vegetation and rock types are useful indicators of soils, soil testing should be used to more precisely determine soil fertility, acidity and nutrient status.

Acid Soils

Acid soils predominate in the region. Technically, an acid soil is any soil with a pH below 7. However, as many plants prefer a slightly acid soil, some degree of acidity is not a problem.

Problem acid soils only occur when the pH($CaCl_2$) falls below 5.0.

What is Soil pH[1]?

Soil pH is simply a measure of acidity or alkalinity of the soil solution. Values range from 0-14, those below 7 being acid and those above, alkaline.

The majority of tableland soils have a pH in the range of 4.0 to 5.5.

Problems Found on Acid Soils

Pasture problems commonly encountered in acid soils are:

- difficulty in establishing lucerne and phalaris
- thinning of sub clover
- poor responses to superphosphate
- a reduction in carrying capacity and increased presence of weeds, such as dandelion and sorrel

Several specific soil chemical and biological problems have been identified in acid soils. The more important of these are:

- aluminium toxicity
- manganese toxicity
- molybdenum deficiency
- legume nodulation failure

Although poor pastures often result from a combination of these, the most common acid soil problem limiting tableland pasture production is aluminium toxicity.

[1]pH values in this publication are measured in calcium chloride solution (0.01 M $CaCl_2$). pH values measured in water are approx. 0.5–0.8 higher than those measured in $CaCl_2$.

What Causes Soil Acidity?

Soil acidity is caused by a number of factors, including age of the soil, parent rock material, rainfall and organic matter levels. Some soils are naturally quite acidic, that is they have a low pH and soil acidity problems even in their natural, timbered state.

Pasture improvement has led to an increased rate of acidification in some of our soils. Improving pastures using legumes and fertiliser usually gives rise to a slow accumulation of organic matter and this in itself tends to acidify soils. However, a more important effect is associated with the introduction of legumes because these contribute nitrogen to the pastures and soil.

If this nitrogen is washed from the root zone (leached), there is an increase in soil acidity. The greater this loss the more rapid the rate of acidification. For example, an annual pasture with legumes will acidify at a faster rate than a perennial grass pasture with legumes. This is because perennial grasses' extended growing season and greater root depth enables them to trap legume nitrogen before it leaches from the root zone.

Some fertilisers e.g. those containing ammonia or elemental sulphur, can also increase the rate of soil acidification, ***Superphosphate, contrary to popular opinion, does not directly cause soil acidity.*** However, by promoting greater legume growth and thus nitrogen fixation, it can indirectly contribute to increased acidity.

Another important cause of acidification is the removal of organic products, especially if they are high in calcium, magnesium and potassium. Products such as lucerne or clover hay are very high in these elements compared to cereal grains, so removing a tonne of hay is much more acidifying than removing a tonne of grain. Removal of most animal products (except milk) also has little effect on soil acidity, so an area cut for hay will acidify faster than a grazed area due to the greater rate of product removal.

What To Do If You Suspect Acid Soil Problems

To define an acid soil problem, soil testing is essential. The first step is to determine the soil pH level in ***both topsoil and subsoil***, to indicate what problems may exist and where. If soil pH is low (< 5.0) check other factors such as the aluminium level and CEC.

Testing of subsoils is important to determine if liming, which is basically only effective in the topsoil, can overcome the acidity problem. If the sub-soil is also acid, acidity will still be a problem after liming and affect the survival and production of acid sensitive plants.

Correcting and Reducing Acid Soil Problems

Depending on the severity, soil acidity problems can be overcome. Some remedies have been known and used for years, others are relatively new and research is continuing. There are three main approaches:

1. Tolerant Species

One means of reducing the problems of acid soil is to use tolerant species. Tolerance to acid soils, especially aluminium toxicity, varies between pasture species as shown in Table 4.2.

Table 4.2. Sensitivity to Soil Acidity and Aluminium % of a range of pasture species - based on threshold levels to cause a 10% decline in yield *

Pasture	Aluminium Tolerance category	Al (%)	Approx. pH
Lucerne & Medics	Highly sensitive	2–8	4.5–4.9
Phalaris seedlings	Sensitive	8–12	4.3–4.5
White & Sub clover	Tolerant	12–21	4.2–4.3
Tall fescue & Ryegrass			
Cocksfoot	Highly tolerant	21–30	4.1–4.2
Microlaena			

**Applies to most fertile topsoils. Values are higher for highly weathered infertile soils and lower for recently fertilised or saline soils.*

However, while changing to more tolerant species can be a useful stop-gap, it does not rectify an acid soil problem which may continue to worsen.

Tolerant species are often used in conjunction with liming, especially where soil acidity occurs in the sub-soil.

2. Liming

The best way to treat acid soils, but also the most expensive, is to apply a liming material. Lime will raise soil pH, convert soluble and exchangeable toxic aluminium to harmless insoluble forms and overcome any calcium deficiency. Remember however, liming will really only treat the top-soil.

To obtain the full benefit from liming two factors are critical:

(i) Neutralising value (NV). This tells you how effectively the liming material will neutralise soil acidity. Pure limestone (calcium carbonate) has a NV of 100. The NV of other products range from as low as 30 to as high as 178.

(ii) Fineness. Lime should be fine, with more than 70% passing a 0.25 mm (60 mesh) sieve. Otherwise, as lime is relatively insoluble, reaction with the soil will be slow.

The combination of these two factors provides the best indication of the value of the product. For example, a coarse product with a low cost/tonne is not good value

because it will take years to react. However a finely ground product with a low NV, may be quite cost effective if the total product required to achieve a given pH change in the top 10 cm (i.e. equivalent rates) can be bought for a lower total cost.

Other liming materials besides agricultural lime and dolomite can be used effectively, provided they are applied at equivalent rates. There are several other issues in relation to liming:

- **Rate of application.** The lime rate to use depends on several factors particularly soil type. 2.5 t/ha is commonly used on many soils and this will raise the pH from 0.5 to 1.0 pH unit. Higher rates are needed for soils with high CEC values (>4).
- **Mixing with soil.** Preferably, lime should be thoroughly mixed with the soil to a depth of 10-15 cm. However, recent experiments have shown that surface applied lime can move into some soil types quite rapidly e.g. within 1–2 years.
- **Time of application.** To enable it to react with the soil and raise the pH, lime is preferably applied and mixed with the soil at least 6–8 weeks prior to sowing. Where paddocks are to be sown by direct drilling, it is probably best to apply lime 1–2 years before sowing.
- **Over-liming.** Too much lime can be detrimental, particularly on sandy soils. You need to use only enough lime to raise the 0–10cm pH to 5.0, at which point aluminium is no longer a problem.
- **Subsoil acidity.** Remember, after liming and incorporation, sensitive plant species may still perform poorly if the subsoil is acid.

3. Other Soil Treatments

There are less costly options to liming, which can provide short-term solutions to specific acid soil problems particularly when pasture plants are vulnerable i.e. as seedlings. Two treatments which can be used are:

- **Inoculation, lime pelleting and molybdenum use**

  Acid soils make legume nodulation difficult. In addition, the trace element, molybdenum, rapidly becomes deficient in acid soils. This element is necessary to allow the legume nodule bacteria to fix nitrogen in the soil.

  All legumes should be inoculated, lime pelleted and treated with Mo prior to sowing for effective nodulation.

- **Lime-super mixes**

  These are often used to aid establishment in marginal acidity situations. They can assist pasture establishment during the first year where the seed is drilled in rows. There is likely to be little liming effect in subsequent years when the plants spread out from the rows. However, experience in the Goulburn district suggests that Australian phalaris can be established in quite acid soils using this method. It appears that once plants get through the seedling phase they can be quite persistent.

It should also be noted that most commercial lime-super mixes are relatively expensive. They have a reduced liming value and their phosphorus is less available.

Points to Remember

- Soil types and soil characteristics vary greatly even on a paddock scale.
- Many tableland soils are acidic and of low to moderate fertility.
- Aluminium toxicity is the most common acid soil problem but only when pH is below 4.5.
- Soil testing is essential to define and determine the extent of the problem.
- Liming is most effective where acidity is confined to the top soil.
- Acid tolerant species must be used when soil acidity extends to the subsoil.

Further Information

NSW Agriculture publications:

Agfact AC.19 *Soil acidity and liming.*
Agfact AC.15 *Liming materials.*
Agnote Reg 5/113 *Soil acidity in agriculture.*
Agnote Reg 5/115 *Looking at liming? How much do you need?*
Agnote Reg 5/118 *Looking at liming? Try a test strip.*
Agnote Reg 5/119 *Looking at liming? Think about quality.*
Agnote Reg 4/50 *Soil testing for pastures and crops.*

Duncan, M (1999). Pastures and acid soils. Leaflet No. 6. *Acid Soil Management Series,* NSW Agriculture, Acid Soil Action.

Fenton, G (1999). Planning on liming. Leaflet No.4. *Acid Soil Management Series,* NSW Agriculture, Acid Soil Action.

Schumann, B (1999). The causes of soil acidity. Leaflet No. 5. *Acid Soil Management Series,* NSW Agriculture, Acid Soil Action.

5. PASTURE ELEMENTS

In managing any pasture it is necessary to be able to identify what plants are there. Botanists always require flowers to positively identify a plant species. However, when managing pastures, it is often necessary to identify plants when they are either very young or in a grazed (vegetative) state. To assist you in identifying various pasture plants, distinguishing features such as rolled versus folded leaves, auricles and ligules are mentioned. **Figures 5.1** and **5.2** will clarify some of these botanical features.

The Balanced Pasture

The 'ideal' pasture contains a balanced mixture of grass and legume. Although 70% grass and 30% legume is often quoted, the proportions of grass and legume will vary with the pasture type.

Well balanced sown pasture.

Legumes are important in pastures because they have nodules on their roots which contain bacteria that can fix nitrogen from the air and change it to a form that plants can use. A vigorous legume component will provide 25 kg of nitrogen per tonne of dry matter grown.

When operating a high producing crop/pasture rotation, target legume dominance in the final year of the pasture ley. In contrast, avoid clover dominance in spring with native pastures otherwise species like wallaby grass and red grass become smothered and will thin badly.

Highly grass dominant pastures often lack vigour due to nitrogen deficiency and livestock growth is suppressed by the reduced feed quality (digestibility). Higher legume levels produce a more digestible pasture and thus higher animal production is possible. However, be aware that bloat can occasionally be a problem in legume dominant pastures, especially with cattle.

In long-term perennial pastures learn to recognise when the legume percentage is too low for continued pasture vigour and acceptable livestock production. If legume ground cover falls below 15%, especially if the legumes are also small, discoloured and lack vigour, then some pasture management intervention is necessary to promote the legume component.

Grasses and Legumes

Botanists differentiate grasses from legumes by the number of seed leaves that are first produced when the seed germinates. Grasses are monocots having only one cotyledon or seed leaf compared to legumes which are dicots, having two cotyledons or seed leaves.

There are other major differences. The leaves of grasses don't have a distinctive stalk but grow straight off the stem. They are usually long, thin and strap-like and the leaf veins are usually parallel. The root system of grass plants is fibrous. Most people don't consider grass plants to have flowers in the way we normally think of flowers. However, grasses do have flowers, they just tend to be very small and indistinct.

Pasture legumes often have leaves comprising three leaflets (imagine an Irish shamrock). The flowers of legumes are distinctive and help to identify legume species. The flowers vary in colour from white, pink, red, purple or yellow, and can grow on their own (sub clover), or in dense clusters (white clover). In a grazed pasture, leaf and stem features such as shape and the presence or absence of hairs are also used. Seeds are often contained in pods or burrs.

Figure 5.1 Stylised Grass Showing Key Features

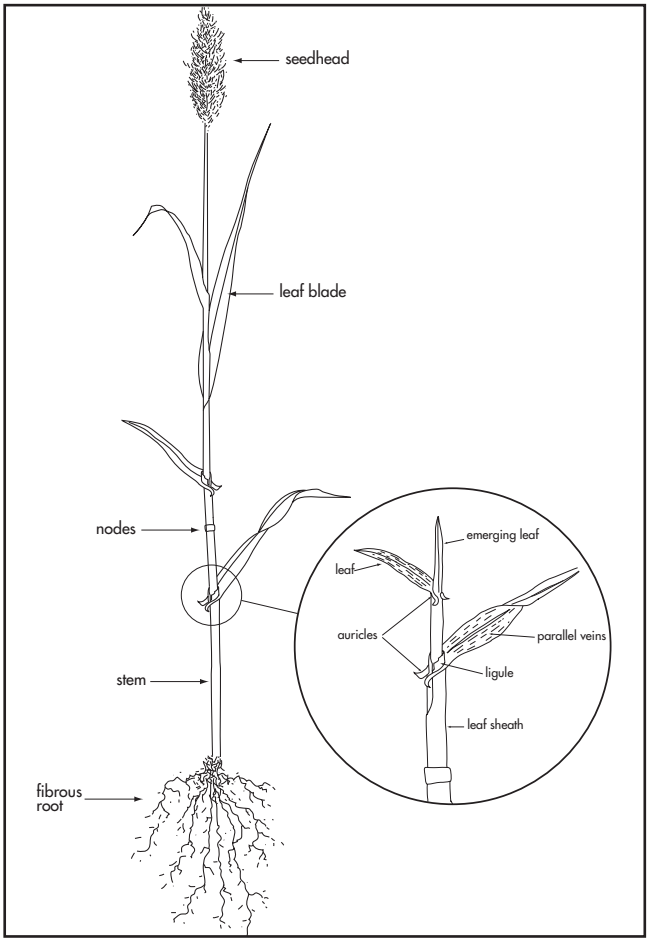
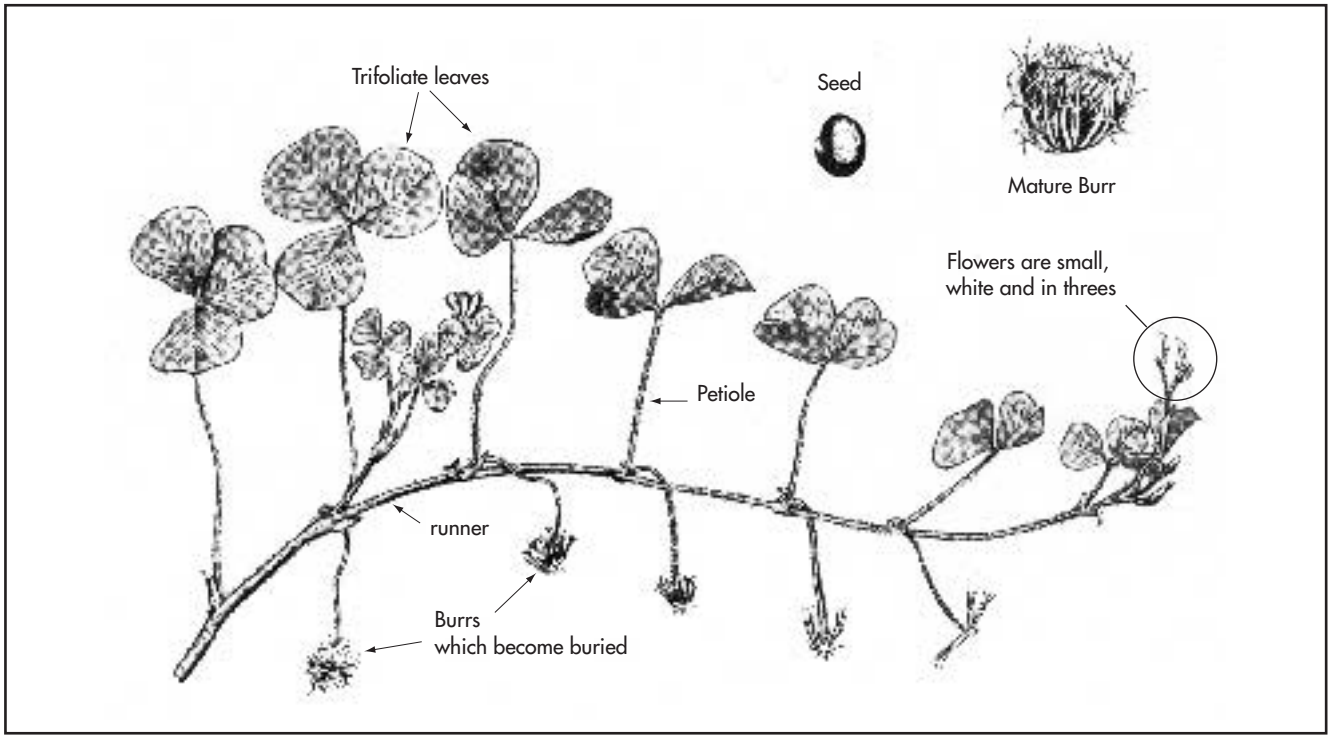


Figure 5.2 Stylised Sub Clover Showing Key Features



For further details about identifying specific pasture species refer to the notes in Chapter 7 of this publication for native and naturalised species and *Management of Profitable and Sustainable Pastures* (1996) pp 13–14 NSW Agriculture publication. ISBN 0 7310 5732 5. Available direct from NSW Agriculture, PO Box 408, Queanbeyan 2620, (02) 6297 1861.

Perennials and Annuals

Compared to annual pastures, perennial pastures have advantages for both livestock production and a range of sustainability issues. These include:

- a longer growing season, the ability to respond to summer rains and generally greater resilience to drought
- deeper roots which result in greater water use throughout the soil profile and can lower water tables, reduce salinity and improve paddock trafficability during winter
- lower nitrate losses from leaching (intercepted by the deeper roots of the perennial) and thus reduced soil acidification
- more permanent ground cover and greater pasture competition leading to less weeds and reduced weed control costs
- reduced erosion potential and nutrient run off into streams via greater groundcover, especially in late summer/autumn when annuals are not present and high intensity storm rainfall is more likely
- in crop rotations, perennial grasses can markedly improve soil structure.

Pasture Mixtures

Maximum livestock performance depends on the presence of green leaf for grazing. This is best achieved by having a range of species available, not necessarily in the same paddock, but at least on the property as a whole.

It is often common practice to sow a bit of this and a bit of that and where there is large paddock variability in soils, aspect or drainage this is wise. For example, where a paddock has very wet and very dry areas, sowing a mixture of fescue, phalaris and subterranean, white and strawberry clovers will ensure good persistence on the dry ridges (phalaris and sub) and good summer growth in the wetter areas and on the protected slopes (fescue, white and strawberry).

However, in relatively uniform paddocks, sow only one grass species, best suited to that paddock. Grazing management is easier and greater control of pasture growth and composition is possible where a single species is sown. Single grass species pastures are preferable for sheep. Their ability to be highly selective in what they eat means they can easily overgraze the most palatable of two or more grasses, causing one to die out.

Physical features are also important in deciding what to sow. Semi or non-arable areas for instance, should be either sown to a persistent species, such as Australian phalaris that won't need to be sown again or managed to promote any desirable native perennial grasses already present. Conversely, a highly fertile, well-drained, creek flat may be best sown to lucerne, chicory or even a high producing ryegrass pasture.

Points to Remember

- Legumes are vital for livestock production and pasture vigour –70% grass and 30% legume is a rough rule of thumb.
- Perennial pastures are more sustainable than annual ones.

6. SUSTAINABLE PASTURE DEVELOPMENT

Research by NSW Agriculture and CSIRO has highlighted the value of pastures based on introduced species or fertilised native pastures with an introduced legume. Both can provide:

- higher carrying capacity
- better quality and quicker livestock turnoff
- increased enterprise flexibility
- increased reliability of production
- higher profits, and
- an improvement in a number of environmental aspects.

However, just associating short-term productivity (e.g. increased stocking rate) with long-term profit ignores the need for a whole farm approach that is harmonious with the natural resource base and sustainable pastures.

Pasture areas in this region that might be considered for development will fall into three major categories:-

(i) Paddocks following cropping with no useful perennial pasture species.

(ii) Old run-down sown pastures that have become weedy and contain few useful perennial pasture species.

(iii) Native pastures.

Decisions about situation **(i)** revolve around the most suitable type of pasture to sow for the length of the pasture phase and the livestock targets to be met by the paddock. Species sown will generally be introduced (annual and/or perennial).

The important questions to ask in situation **(ii)** are:

- why did the sown pasture fail to persist?
- were the sown species suited to the soil, topography, aspect and livestock usage?
- are perennial native grasses now an increasing component of this pasture?

If the answer to the last question is yes, then consider carefully whether pasture development should be based on what would appear to be poorly adapted introduced species.

In situation **(iii)**, the traditional attitude to native pastures has often involved lax management and low stocking rates, resulting in poor pasture quality and productivity, especially if they are dominated by frost susceptible species. This leads to inefficient livestock production.

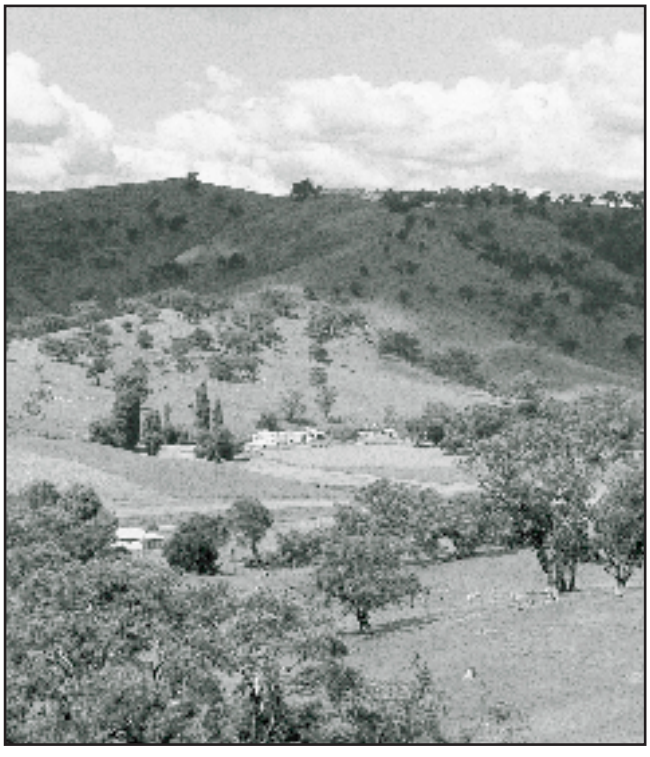
Some native pastures have a lower capacity for plant growth than introduced species (particularly during late autumn/winter/early spring) as well as marked seasonal production (often spring-summer). Feed quality declines quickly with maturity but especially when such species become frosted.

Other native grass pastures however can be very productive (see chapter 7). Applying fertiliser, introducing a legume and targeting management to increase the more productive, winter green native component (particularly wallaby grass and microlaena) may boost productivity more than sowing poorly adapted exotic species.

What Factors Affect Pasture Development Options?

Five major factors determine where native, modified native, or introduced perennial grass/legume based pastures are best suited. These are:

- land class
- slope/erodibility
- soil acidity
- aspect, and
- drought persistence.



Tableland landscapes exhibit wide variability.

Table 6.1 shows the suitability rankings of pasture types according to slope, acidity and soil fertility. Establish clear objectives before modifying or developing pastures. The most common objective is to improve the feed supply. As far as practical, match the feed requirement to the most suitable plants for your soil type, climate, resources and objectives.

Pasture persistence and maintenance of ground cover should be the prime focus when considering development options on steeper, more erodible soils.

2. Soil Acidity

Highly acid soil sensitive pasture species, for example, lucerne and phalaris, may not persist or perform well

Table 6.1 Interactions between pasture type, soil factors and long-term pasture productivity

Pasture Type	Suitability to Slope[1]			Suitability to Soil Acidity[2]		Suitability to Soil Fertility	
	Flat[3]	Undulating[4]	Steep[5]	Low	High	Low	High
Native - no fertiliser or legumes (Summer growing spp., e.g. kangaroo and red grasses)	*	**	*****	*	***	***	*
Native plus legumes/fertiliser (year long green spp., e.g. wallaby grass, microlaena)	**	****	*****	***	*****	*****	****
Degraded introduced pasture (dominated by annual grass and broadleaf weed).	**	**	*	**	*	**	**
Introduced pasture with perennial grass plus fertiliser and legumes	*****	****	**	*****	**	****	*****

Note: More * indicates better performance over time.**

1) Related to persistence and production of perennial pasture, ground cover and steepness of land. 2) Low acidity = pH ($CaCl_2$) 4.5-5.0; High acidity = pH <4.5 in top and subsoil & aluminium >12%. 3) Arable. 4) Sow by direct drill or aerial means. 5) Can only be improved by aerial means.

To efficiently match feed supply with demand, examine your livestock enterprise/s to identify when the demand for quality feed is required to meet market specifications. This concept is a key premise on which the NSW Agriculture developed PROGRAZE workshops are based.

1. Slope/Erodibility

Less than 10% of the high rainfall tableland areas are arable or based on basalt soils where the risk of erosion from cultivation is minimal. The balance comprises soil types which include highly erodible granites and sedimentary duplex soils. Cultivation on these soils poses a high erosion risk, particularly when carried out over summer-autumn during the high intensity rainfall period.

Remember it is futile and self defeating to destroy existing stands of native perennial grasses when they cannot be replaced by a pasture mixture which, over a wide range of seasonal conditions, will be equally persistent and provide permanent ground cover.

Some steep, erodible or skeletal soils may best be fenced out and retired from agriculture for conservation purposes (revegetated with trees or only lightly grazed periodically).

where there is subsoil acidity, even when lime has been incorporated at rates up to 5.0 t/ha prior to sowing. By contrast, microlaena, cocksfoot and some wallaby grass species are extremely acid soil tolerant and are the preferred grasses where there are acid subsoils.

As outlined in Chapter 4, acid soils can often be recognised by the native timber and pasture species present. Peppermint, white or brittle gum, scribbly gum, she oak, ironbark and sifton bush nearly always indicate strongly acid soils. Similarly, wiregrass *(Aristida spp)*, microlaena and some wallaby grasses are also highly acid tolerant and where they dominate, it is likely soils are acid. Conversely, yellow box and red grass *(Bothriochloa)* tends not to grow in strongly acid soils.

3. Soil Fertility

High levels of production are only achieved by well-nourished pastures either from naturally fertile soils or applied fertiliser. Introduced pasture species in particular require and respond to increased soil fertility. However, the more desirable yearlong green native grasses, although able to tolerate lower fertility and acidity, also respond well to increased fertility.

Where Do Pastures Best Fit?

Development and management decisions for individual paddocks should not be made in isolation. Whole farm planning needs to consider all resource factors as a total package and requires holistic management for sustained profitability. Sustainability is also directly linked to maintaining the ground cover of perennial grasses. Keep in mind the need for a whole farm approach that is harmonious with the natural resource base and sustainable pasture and revegetation development. This approach should be compatible with the broad aims of catchment management.

Development and management strategies must ensure that all areas of a property are used in the most effective and sustainable way. As outlined in **Table 6.1**, there are four broad pasture situations. These are:

- Predominantly summer growing native perennial grasses (kangaroo grass, red grass and wiregrass etc.) with no fertiliser or legume
- native perennial grasses (wallaby grass, microlaena, *poa*, spear grass *(Austrostipa)*, *Bothriochloa* etc.) in association with introduced annual legumes and limited fertiliser applications
- high input/high output replacement pasture systems based solely on introduced pasture species (e.g. phalaris, ryegrass, cocksfoot, fescue, clovers) and intensive fertiliser and livestock management
- older, degraded sown pastures based on introduced species, now including weeds, annual grasses, etc., with low fertiliser and stock management inputs.

All have strengths and weaknesses from an agronomic, livestock, economic and conservation viewpoint. Most tableland farms have a diversity of soil types, aspect, pasture types and enterprise needs which enables a wide range of pasture and livestock management options to be utilised.

There are two formal courses that are valuable in making these types of decisions on a whole farm basis.

1. Property Management Planning

A property plan helps to develop long-term goals, to increase understanding of resource management issues and to set priorities so funds are directed for appropriate development and management options. Landholders can prepare their own plan in a workshop with guidance from staff from NSW Agriculture, Department of Land and Water Conservation and National Parks and Wildlife Service.

2. Managing Soils and Landscape Resources

NSW Agriculture is currently developing a workshop series to help landholders decide how best to manage and develop their paddocks depending on soil and landscape features.

The workshops are modelled on the very successful PROGRAZE format with six sessions. Participating farmers will gain skills in, for example, reading and interpreting major landscape features, taking and interpreting soil tests, selecting the right fertiliser including rates and timing. Workshop participants will have the opportunity to undertake extensive soil testing at a very competitive rate.

Points to Remember

- There is no perfect grass or legume; all species have strengths and weaknesses for both livestock production and conservation.
- Slope, rainfall, acidity and fertility requirements are the four most important factors that determine which pasture type is most suitable.
- Match feed supply to enterprise feed requirement.

7. NATIVE AND NATURALISED PASTURES

An extensive survey of native grass pastures on the central and southern tablelands and Monaro in 1991–92 by Garden *et al.* (in press) found that native grasses were dominant in many areas and microlaena, wallaby grass and annual grasses appeared to have replaced sown species in many paddocks. The most common species on the central tablelands were red grass, wallaby grass species and microlaena, on the southern tablelands wallaby grass species and microlaena and on the Monaro, wallaby grass species, *poa* spp., kangaroo grass and spear grass (*Austrostipa* spp.).

Significantly, the survey found farmers had non-destructively manipulated their pastures to increase the percentage of the useful native species using grazing management and fertiliser. Around Goulburn another survey by Munnich *et al.* in 1991 found that useful year-long green species such as wallaby grass and microlaena were present at levels of 10–20% in many previously sown paddocks.

Growth and Production Patterns

Different grasses have varying growth periods, herbage quality, responses to soil fertility, tolerance to grazing and to drought. Understanding these differences is the bottom line for management.

Broadly, winter/spring active species flower and set seed in mid to late spring (e.g. wallaby grass and annual grasses) while summer growing species flower and set seed in mid to late summer depending on rainfall (e.g. microlaena, red grass and kangaroo grass).

However, some species (e.g. wallaby grass and microlaena) can flower and set seed in both spring and autumn which helps managers to increase the density of these species using grazing management.

The variability of summer/autumn rainfall in the tablelands and the inability of introduced pasture species (other than lucerne and chicory) to reliably provide high quality feed during summer and autumn creates problems in a breeding enterprise, especially for weaner sheep.

Traditionally, tableland environments had a winter feed shortage. This was filled to some extent by sowing introduced pastures with better winter productivity. However, where summer growing native pastures were replaced, a quality feed shortage in summer/autumn was brought about. Both types of pasture have a place within the whole farm context.

Features of Common Native Perennial Grasses

- *Austrodanthonia spp* (formerly *Danthonia* spp.) - **Wallaby grass or White Top**

  There are over 20 different species of wallaby grass. They comprise a wide range of types and some are considered very valuable yearlong green species. They are drought tolerant, respond positively to fertiliser and grazing, are palatable and frost tolerant. Leaves are deep green to blue-green, most species having fine hairs but some are hairless. There are two distinct tufts of hair where the leaf joins the stem. The fluffy seedheads turn white on maturity.

- *Microlaena stipoides* - **Microlaena, Weeping Grass, Rice Grass**

  A low growing perennial with short rhizomes, that can remain green all year. Microlaena responds positively to increased fertility and grazing and is acid soil and shade tolerant. Frequency increases when rainfall exceeds 650 mm with a summer incidence. Leaves are 2–5 mm wide with scattered fine hairs, blue-green to lime green in colour, rolled in the stem and often have a small kink in the leaf margin close to the tip. The auricle wraps around and there is a short membranous ligule. The fine weeping seedhead is fine stemmed and turns golden on maturity.

- *Bothriochloa macra* - **Red Grass, Red-leg Grass**

  A summer active, winter dormant perennial forming prostrate tufts. The hairy leaves are palatable and digestible, but the stems are not. Responds positively to grazing but does not survive well on acid soils. It is drought tolerant and adaptable to a range of soil fertility. Leaves are rolled with a prominent midrib. The stem is rough, often with smooth reddish nodes. There is a short membranous ligule. Leaves and stems are usually reddish or purplish particularly after frost. The seedhead has 2–4 prongs all aligned vertically from the end of the seed stalk.

- *Themeda triandra* - **Kangaroo Grass**

  Widespread across Australia, this tall tufted summer active, winter dormant perennial grass is drought resistant but does not tolerate continuous grazing, soil acidity, or increasing soil fertility very well. Survives winter burning. Compared to red grass, it is distinguished by folded leaves, a red-brown tinge on older leaves and rusty coloured seedheads with the characteristic paw shape.

- *Aristida ramosa* - **Wiregrass, Three-awn Speargrass**

  Often considered agriculturally useless, this tussocky perennial grass produces little feed of low quality and palatability. Seedheads are a major problem and penetrate wool, skin and eyes of sheep. Fortunately 'sub and super' in the 1950's and 1960's converted many pastures dominated by this species to 'better' native species such as wallaby grass and microlaena. It now tends to be restricted to low fertility, acid soils. Clusters of branches often grow from aerial joints. Seedheads are purple coloured with three awns (*Stipa* spp. have only one awn). Ligules are very short, and leaves are narrow and rolled.

- *Poa* **spp. - poa Tussock, Snow Grass**

  Poa species are complex-the two most common are *P.sieberiana* (Snow grass) and *P.labillardieri* (poa tussock). These tufted year long green perennials grow from 50–150 cm tall and are very drought hardy. Poa responds to increases in soil fertility and grazing. *P.sieberiana* can provide useful feed in winter if well managed. Generally feed quality is medium to poor, with low palatability. Under set stocking *poa labillardieri* can invade and dominate other pasture species. Leaves are hairless, grey-green up to 30 cm long, have a rough feel and no ligule. Seed heads are open panicles with clusters of small green to purple spikelets.

- *Austrostipa* **spp.** (formerly *Stipa* **spp**) **- Spear Grass, Corkscrew Grass**

  Austrostipa species are numerous, widespread, and common throughout the region. Most of the species grow actively in spring and early summer, but some make active growth in late autumn/winter. Forage value is medium (green leaf has 9–12% crude protein and digestibility from 60–66%). Palatability can be a problem. Some species have sharp, pointed seedheads with twisted awns when mature, which, like wiregrass, will harm livestock and increase vegetable matter fault in wool.

- *Elymus scaber* - **Common Wheatgrass**

  This tufted, relatively short-term but palatable perennial makes rapid leaf growth in autumn and winter. The long, thin leaves are velvety, very soft to touch and usually twist as they extend. The membranous ligule is well developed but auricles are small.

  It is most noticeable in spring when it puts up its characteristic wheat-like seedhead with long awns which curl out at maturity. Another identifying feature is that the upper leaf on the seedhead stalk is held at right angles to the stalk.

A stable and productive pasture is one that contains a mixture of perennials and annuals, but is not dominated by annual species.

Most paddocks contain a diversity of native and naturalised perennial and annual species including grasses and legumes.

Features of Naturalised Species

Naturalised species are those that have been introduced into Australia and have successfully spread without being deliberately sown. The most widespread naturalised species can be placed in three broad groups.

• *Annual Grasses*

The four most widespread annual grasses are vulpia (rat's tail fescue or silver grass), barley grass, wimmera ryegrass and brome grass. They all germinate after opening autumn rains and grow during winter/early to mid spring. They can provide useful quantities of green leaf (depending on the timing of the autumn break) in late autumn/winter, which is of medium to good quality.

Annual grasses seed prolifically and some cause grass seed problems in sheep. Where dominant they can increase soil acidity as their shallow roots are unable to capture water and prevent nitrate leaching. They also result in bare ground in late summer/early autumn, which increases the risk of surface erosion and broad leaf weed invasion.

• *Annual Legumes*

The most widespread annual legumes on the tablelands include ball clover, suckling clover, hop clover and haresfoot clover. These all have a similar growth pattern to the annual grasses, but provide very little feed during the winter (usually less than 1000 kg/ha). They produce the bulk of their feed in mid to late spring, respond to fertilisers but are less reliable than subterranean clover.

• *Naturalised Perennial Grasses*

The most common naturalised perennial grasses include Yorkshire fog, paspalum, dryland couch and bent grass. All these grasses can provide feed of moderate quality in mid to late spring/summer. They are very competitive and can cause livestock production problems where they dominate due to low feed quality and palatability. Yorkshire fog is probably the most useful because it can be year-long green and of medium to high quality when managed to keep it green and leafy. Paspalum is very productive in wet summers and will sustain very high stocking rates but like couch and bent becomes frosted and valueless in winter.

How Land Class Influences Development Options

Based on NSW Agriculture's classification of suitability for agricultural production the majority of land in the

region is class 3 or 4 i.e. suitable for grazing with occasional cropping or solely suitable for grazing. There is very little, if any, class 1 or 2 land and class 5 should remain under timber.

Class 4 land can be divided into that which is trafficable and that which is non-trafficable. The most economically and environmentally sustainable method for increasing the productivity of pastures in non-arable hill country in most situations will be non-destructive pasture development and management options. The use of these will minimise the risk of reducing ground cover or causing degradation. This strategy is also the most suitable one for acid soils with subsoil acidity.

Promoting or maintaining species already well matched to your soil type and having the productive potential to suit your enterprise needs, will provide ground cover as well as long-term sustainable and profitable production.

High input sown pastures are best restricted to small pockets of class 1/2 and the better class 3 country. As soils become poorer (less fertile), shallower or slope increases, the balance between agricultural productivity and conservation goals become more important. If Australian phalaris cannot be reliably established and managed as the basis of your pasture, other introduced perennial grasses (e.g. ryegrass, fescue, cocksfoot) are unlikely to persist. The major focus in class 4 country is to maintain ground cover with native grasses or in some situations, timber.

Table 7.1 broadly indicates characteristics of the main native and naturalised grasses present in the region including their grazing value.

Native Vegetation Act

The *NSW Native Vegetation Conservation Act, 1997*, outlines management and approved development options for both native pastures and native vegetation. Contact the Department of Land and Water Conservation before embarking on any whole farm development plan involving native species.

Development Options for Native Pastures

For most semi-arable to non-arable landscapes, particularly those associated with low fertility acid soils, the most sustainable development options will be based on non-destructive strategies. By far the most common is to oversow an annual legume, e.g. subterranean clover, combined with a low input of fertiliser, e.g. 125 kg/ha of single superphosphate.

The aim is to slowly modify the pasture with a winter growing species to produce quality green feed. The legume will also improve soil fertility and encourage the year long green species such as wallaby grass and microlaena. Examples of this approach and the results over time from Bathurst and Yass are outlined below.

Bathurst: On hilly slate/shale country, supplying deficient nutrients phosphorus and sulphur to a red grass dominant native pasture using superphosphate plus aerially sown sub clover increased stocking rate from 2 dse/ha to 6–8 dse/ha over 12 years (1966–77).

This approach increased stocking rates by 5 dse/tonne of superphosphate applied as shown in **Figure 7.1**. The

Table 7.1 Major features of some common native and naturalised grasses

Common Name and Category		Botanical Name	Drought Persistence	Acid Soil Tolerance	Grazing Response	Herbage Value (*)	Fertility Response
Kangaroo grass	S	*Themeda triandra*	H	L-M	L	L-M	L
Red grass	S	*Bothriochloa macra*	H	L-M	H	M	M
Wiregrass	S	*Aristida ramosa*	H	H	L	L	L
Wallaby grass (white top)	Y	*Austrodanthonia* spp.	H	H	H	M-H	M-H
Weeping grass	Y	*Microlaena stipoides*	H	H	H	M-H	H
Poa Tussock	Y	*Poa* spp.	M-H	M-H	M-H	L-M	M-H
Spear grass	Y	*Austrostipa* spp.	M-H	M-H	M-H	L-M	L-M
Wheat grass	Y	*Elymus scaber*	M-H	M-H	M-H	M-H	M-H
Brome grass	A	*Bromus* spp.	L-M	H	M-H	L-M	H
Rat tail fescue (Vulpia)	A	*Vulpia* spp.	H	H	H	L-M	M-H
Barley grass	A	*Hordeum leporinum*	M-H	H	M-H	L-M	H
Yorkshire fog	NP	*Holcus lanatus*	M	H	M	M-H	M-H
Paspalum	NP	*Paspalum dilatatum*	M	H	M-H	M-H	M

S = Summer growing native
NP = Naturalised perennial
H = high
Y = Yearlong green native
(*) = Herbage value based on green leaf
M = medium
A = Annual grass
L = low

higher carrying capacity has been maintained for a further twelve years by applying single superphosphate at 125 kg/ha every second or third year, depending on seasonal conditions and cash flow.

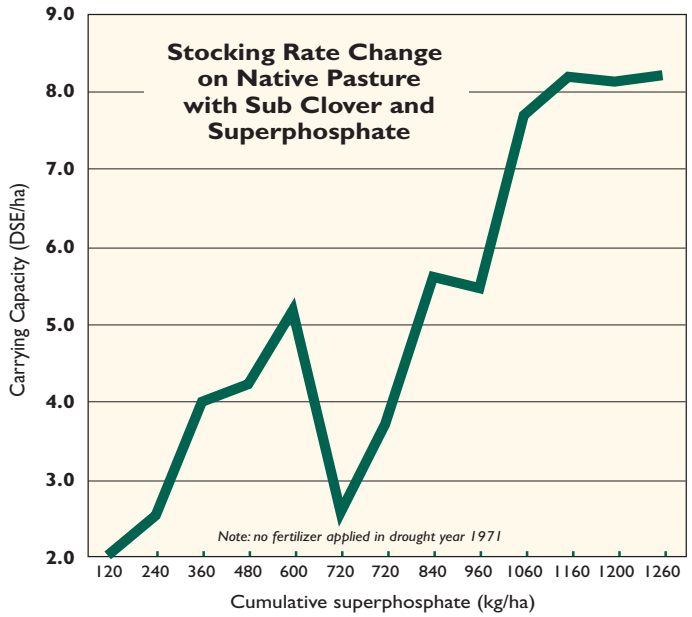
Pasture composition changed over time from mainly red grass to a diverse but stable mix of red grass, wallaby grass and microlaena plus annual legumes, annual grasses and some broadleaf weeds.

Yass: Livestock performance on unfertilised and fertilised native perennial grass pasture (mainly microlaena and wallaby grass) has been compared at Yass since 1994. The paddock was originally wiregrass dominant when cleared in the 1950's and after 20 years of sub and super, has had little if any super applied in the last 20 years.

The paddock was divided in two, one half being fertilised with 125 kg/ha single super each year. The other half remains unfertilised. Wether bodyweight was monitored every six weeks initially and stocking rate adjusted to maintain a similar livestock weight in both paddocks. Average stocking rate over the six years on the fertilised paddock has been 12 wethers/ha while the unfertilised paddock has carried 6.3 wethers/ha. Fibre diameter and individual fleece weights have been similar. The proportion of legumes in the fertilised paddock has increased significantly while the level of native perennials in both paddocks is unchanged.

Averaged over the six years, 1994 (a drought year) to 1999, clean wool/ha was 39.9 kg fertilised versus 20.7 unfertilised. Net profit per hectare per annum averaged $72 from the fertilised paddock versus $35 from the unfertilised one.

Figure 7.1. Native pasture development with sub/super at Bathurst



Points to Remember

- Native grasses vary widely in their value for livestock and their response to acidity, waterlogging, grazing and fertility.
- It is important to recognise the plants that grow in your paddocks. Knowing their different responses to a range of factors is the key to their successful management.
- Native pastures may be non-destructively modified to substantially increase stocking rate using 'sub and super' and this may be a better economic option than replacement.
- Pastures are dynamic but should be monitored to arrest undesirable changes.

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Agfact P2.5.39. *Wallaby Grass - a domesticated native grass*

8. INTRODUCED PASTURE SPECIES

Although developed native pastures are of immense value to the grazing industries, the injection of introduced species can complement the feed supply with improved quality and quantity of feed and reliability of production throughout the year. **Table 8.2** at the end of this chapter, summarises the key characteristics of various introduced pasture species and their seasonal production potential.

Due to new pasture varieties being released over time, consult the district pasture recommendation insert accompanying this book, when selecting a particular variety for specific uses.

Legumes

Legumes are an essential component in all developed pastures. They produce high quality feed and are a rich source of nitrogen for pasture grasses and following crops. Sowings of introduced species should result in a legume balance of about 30% (by dry weight). The most productive legumes have been introduced. Some have become naturalised, (e.g. suckling, hop, haresfoot, cluster clover, burr medic) and occur commonly in natural pasture.

Autumn sowing is essential for annual legumes but perennial legumes can be sown successfully in both autumn and spring (see chapter 10–Pasture Establishment).

Lucerne *(Medicago sativa)*

Lucerne is a drought tolerant, deep rooted, summer growing perennial. It prefers deep to well drained soils with pH($CaCl_2$) 5.0 or above. Lucerne is particularly sensitive to aluminium. Establishment is relatively easy provided insect pests are controlled and stands will remain productive for 5–10 years given careful rotational grazing management.

Select varieties on the basis of winter growth rating and resistance to insects and diseases. Resistance to Phytophthora root rot and at least some resistance to Colletotrichum crown rot should also be considered, particularly for irrigated stands. Semi winter-dormant and selected winter-active varieties are very adaptable as all-purpose lucerne varieties. Highly winter active varieties are mainly used for short-term pastures. Winter dormant varieties tend to be lower crowned and have the best persistence when used in mixed pastures where ideal management is not always provided.

Subterranean clover *(Trifolium subterraneum)*

The most important legume used in the region. Most varieties of this winter-growing, self-regenerating annual prefer well drained, light to medium textured, slightly acid soils. Yanninicum types are better suited to poorly drained soils whilst brachycalycinum types are best for neutral to alkaline soils. Varieties available provide a range of maturities and give subterranean clover wide adaptability (400 to 700 mm annual rainfall).

Grazing management is critical for good regeneration. Best seed production occurs when sub clover (and companion grasses) is grazed relatively short up until mid spring. Aim to reduce any bulk of summer grass in late summer to enhance good autumn germination.

Select varieties on flowering time (maturity), seed hardness and disease resistance to allow for geographic and climate diversity. A mixture of varieties is therefore preferred, rather than just a single variety.

In higher rainfall, high elevation parts of the region late maturing varieties should be included in mixes. In medium rainfall, lower tableland areas include mid season types. In low rainfall areas or those with very shallow 'hard' soils e.g. ridges and areas with a westerly aspect, use early maturing varieties.

White clover *(Trifolium repens)*

White clover is mostly a perennial, but can also behave as a self regenerating annual. Whilst it can be productive through winter, its main growth is in spring/early summer.

It is adapted to areas of high altitude and performs best in areas with at least 700 mm annual rainfall. It tolerates a wide range of soils from light acid soils to heavy clays. Survival in hot dry periods particularly under heavy grazing is poor, with plants then behaving as annuals. Stock removal during flowering will enhance seed set and thus annual regeneration. Where annual rainfall is marginal but portions of paddocks have poor drainage and remain damp, white clover is still worth including in pasture mixes. As a companion with sub clover and annual grasses, the weak seedling often does not survive.

The legume components of dryland pasture mixes in the region should not be based solely on white clover, due to its unreliable persistence/regeneration. Most varieties set good quantities of hard seed but where being grazed by sheep choose a smaller leafed, stoloniferous variety that roots down at every node rather than the taller, showy, single crown varieties like Haifa.

Serradella *(Ornithopus* spp*)*

Serradella, a self-regenerating winter/spring annual, is ideally suited to deep sandy acid soils with annual rainfall above 400 mm. Most varieties tolerate high levels of exchangeable aluminium and in this regard it is

superior to sub clover.

Dehulled seed is preferred but if only podded seed is available ensure that it is hot water treated to improve germination. Choose early flowering varieties for drier 'harder' situations and mid season types for more favourable conditions.

Pink soft seeded types are worth including as a small percentage of the serradella component. Whilst long-term persistence is poor they give good production in the early years, whilst the better persisting hard seeded varieties establish.

Herbicide choices for broadleaf weed control are much narrower than that for sub clover.

Red clover *(Trifolium pratense)*

Red clover is a biennial or short-lived perennial and performs best where annual rainfall is at least 700 mm. Soil requirements are similar to lucerne – well drained and slightly acid to alkaline. Its main use is as a short-term pasture for grazing (especially with short-term ryegrass), hay, and/or to boost soil nitrogen levels for a following crop. Most growth occurs in spring and summer and whilst it is frost tolerant, winter growth is poor.

Choose low oestrogen varieties to reduce the risk of livestock infertility problems.

Woolly Pod Vetch *(Vicia villosa)*

Woolly pod vetch is a self-regenerating annual legume germinating in early autumn and maturing in late spring. Performance is best in areas of at least 600 mm annual rainfall. Woolly pod vetch is adapted to a wide range of soils from light acid soils to heavy clays.

Vetch persistence is less reliable than sub clover, especially when grazed by sheep. It will establish by air if sown into grass cover, or if drilled into prepared seedbeds. Remove sheep after the autumn break until plants have established and branched out. Graze only lightly in spring of the first year to encourage seed set.

Balansa clover *(Trifolium michelianum)*

Balansa, a self regenerating winter/spring annual, is suited to a wide range of soils from sandy, acid soils to heavy clays. It tolerates waterlogging and has good resistance to root rot and clover scorch. Performance is best in areas of at least 500 mm annual rainfall. It can be useful as part of the legume component in mixed pastures where root rot or clover scorch is a problem – or on its own for hay.

Regeneration from its high proportion of hard seed can however be adversely affected where the small seedlings are in competition with strong sub clover and/or companion grass growth.

Strawberry clover *(Trifolium fragiferum)*

Strawberry clover, a perennial with its main growth in spring/summer/autumn, is suited to areas with rainfall of at least 600 mm. It is slow to establish but exceptionally drought hardy. Its main use is in saline and waterlogged areas and is best suited to slightly acid to alkaline soils.

Caucasian clover *(Trifolium ambiguum)*

A hardy drought tolerant, taprooted, winter dormant perennial legume. The plants have strong rhizomes that give rise to 'daughter' plants enabling the plant to spread and resist heavy, even continuous grazing. It tolerates acid soils.

Other Legumes

An increasing number of alternative legumes are becoming available-each with specific attributes. These include Persian, Arrowleaf and Berseem clovers, lotus species and medics. Seek local advice for more detailed information.

Table 8.2 (p.28) summarises the key features and seasonal growth potential of a range of pasture species.

Grasses

Introduced grasses are divided into cool season and warm season species. Cool season grasses are ideally suited to the region. Warm season grasses should be confined to areas that have reasonable summer rainfall or valley floors with good summer soil moisture and where specific needs exist e.g. summer feed, summer weed control or reclamation areas.

At the same plant growth stage, cool season grasses are generally of higher quality than warm season grasses. Cool season grasses should always be the basis for grass selection in 'mainstream' pasture sowing.

Cool Season Grasses

The four perennial introduced cool season grasses most commonly sown are phalaris, cocksfoot, perennial ryegrass and tall fescue. Three others will also be mentioned.

Phalaris *(Phalaris aquatica)*

Phalaris, performs best in areas of at least 550 mm annual rainfall and on medium to high fertility soils. Whilst it is sensitive to highly acid, high exchangeable aluminium soils especially as seedlings, it tolerates wet and/or moderately saline soils.

It grows mainly from autumn to late spring and has a summer dormancy. Late spring grazing management is a critical factor for persistence of some of the more erect vigorous types. If plants are occasionally allowed to 'run to head' persistence will be enhanced. The older more prostrate 'Australian' type phalaris is rhizomatous and tends to have staggered head emergence making it less sensitive to late spring grazing. Sward life is increased if Australian types are included as part of the phalaris mix.

Always include Australian types where weed control is a focus.

Phalaris litter contains toxins that can inhibit the establishment of sub clover. Excess litter build up (dry matter above 1,200 kg/ha) should therefore be avoided as autumn approaches.

All phalaris varieties contain alkaloids that can at times cause stock poisoning. Veterinary advice should be sought regarding stock and paddock management to overcome this occasional problem.

Phalaris will survive attacks by grass grubs much better than other temperate grasses.

Cocksfoot *(Dactylis glomerata)*

Cocksfoot has superior acid soil tolerance over other introduced grasses. It is relatively easy to establish. While its drought tolerance is better than perennial rye and fescue it is not as good as phalaris. It is best suited to areas with more than 600 mm annual rainfall.

The main growth period is autumn to late spring but some varieties, depending on climate, respond well to summer rain. Whilst it has a slightly lower nutritive value than phalaris, fescue and perennial ryegrass, good nutrition and grazing management will allow it to perform as well as other grasses. It is an important and worthwhile grass for inclusion in mixes where soil variations occur. By selecting varieties with good summer dormancy, persistence may be enhanced.

Cocksfoot responds well to autumn rains and can at times affect the regeneration of subterranean clover. This is often evident where an early autumn 'break' is followed by drier weather – the perennial dries out the soil surface and the sub clover seedlings die. Prolonged heavy grazing (especially with sheep) will quickly thin cocksfoot swards.

Cocksfoot is not as tolerant as phalaris to grass grubs.

Tall Fescue *(Festuca arundinacea)*

Tall fescue, needs good summer rainfall or irrigation for persistence (high altitude tends to compensate to some degree). It performs well in areas above 800 mm annual rainfall. It is the most saline tolerant of the cool season grasses, withstands wet or waterlogged conditions and is moderately tolerant of acid soils.

The main growth period is from autumn to late spring, but it responds well to summer rain. It withstands frosty conditions better than phalaris or cocksfoot, but seedling emergence appears to be restricted by cold temperatures. Tall fescue can at times adversely affect sub clover regeneration because it responds rapidly to autumn rain.

Tall fescue performs best under good fertility and is regarded as a producer of good quality feed. Heavy grazing, especially with sheep in late spring and summer, particularly under dry conditions, will reduce persistence.

Fescues can be damaged by grass grubs.

Perennial Ryegrass *(Lolium perenne)*

Perennial ryegrass is well suited to cool tableland areas with annual rainfall of at least 800 mm. Whilst tolerant of acid soils (but less so than cocksfoot) it requires fertile soil for good production and feed quality. Its main growth period is from winter to late spring.

Its main attributes are ease of establishment, winter production and rapid recovery after grazing. Early maturing varieties are the most persistent.

It has poor drought tolerance and like cocksfoot and fescue, can be attacked by grass grubs.

Caution is needed when perennial ryegrass is included in pasture mixes. As the rate of perennial rye increases, so does the risk of competition to other sown species. Rates in mixtures much above 1.0 kg/ha can result in failure of the slower establishing species.

Tall Wheatgrass *(Thinopyrum ponticum)*

This vigorous perennial grass is best suited to areas above 400 mm annual rainfall where saline and poorly drained situations exist. Its main growth is in spring and autumn. Early autumn sowings are preferred but spring sowings have also proved successful.

Puccinellia *(Puccinellia ciliata)*

Puccinellia, usually sown with tall wheatgrass in saline areas, is a perennial with its main growth in autumn and spring. It is best adapted to wet areas of paddocks. It has a strong summer dormancy, which stresses the importance of an autumn/winter sowing.

Prairie Grass *(Bromus catharticus)*

This short-lived perennial responds very rapidly in autumn and provides good winter and spring growth. Fertile soils are required as is rotational grazing for best regrowth and persistence. It performs best in areas of not less than 850 mm annual rainfall.

Warm Season Grasses

As much of the region has low summer rainfall and a short warm season growing period, the use of these perennial species needs to be considered critically. Late spring sowings are essential.

Their production is variable but depending on species and location on the farm, they can provide green feed at critical times for young stock. Summer grasses 'run to head' much more quickly than the temperate winter growing species. Stock heavily in early summer as unless they are kept in the vegetative stage, quality quickly declines. All species are frost susceptible, with dry standing feed over winter of low quality.

The most relevant introduced summer species are:

Paspalum *(Paspalum dilatatum)*

Paspalum is a spring/summer growing perennial with moderate frost tolerance. It is suited to a wide range of environments, including salinity, waterlogging, acidity and varying soil fertility. It is very tolerant of heavy grazing. Paspalum often colonises valley floors providing valuable green feed over summer. Whilst ergot (a cause of a stock health disorder) can attack seed heads, it is rarely a problem on the tablelands.

Rhodes Grass *(Chloris gayana)*,

Rhodes Grass is a low to moderate quality summer-growing grass, is adapted to a wide range of soil types and has a degree of salt tolerance. It is relatively easy to establish and because of its strong (stolon) growth is extremely useful for erosion control and stabilising earthworks.

Consol Lovegrass *(Eragrostis curvula,* type *Conferta)*

Consol Lovegrass is well suited to light acid soils especially those with high exchangeable aluminium. It is widely used in northern New South Wales for developing acid sandy soils and for controlling spiny burr grass.

As the closely related noxious weed African Love Grass *(Eragrostis curvula)* is declared in most shires advice should be sought before sowing the Conferta type.

Digit Grass *(Digitaria eriantha)*

Digit Grass is a tussocky grass with good tolerance to drought, good persistence and has performed well on light textured acid soils in northern NSW. Whilst well suited to low fertility soils, it has poor waterlogging tolerance.

Herbs

Chicory *(Cichorum intybus)*

Chicory is a highly nutritious summer growing perennial herb preferring good drainage and soil fertility. It will tolerate higher soil acidity than lucerne. For good persistence chicory like lucerne, should be rotationally grazed. In mixed swards animals will selectively graze chicory and care is needed not to damage plants by overgrazing.

Plantain *(Plantago lanceolata).*

Plantain is another highly nutritious, taprooted perennial herb that has been selected and bred in New Zealand. Little production data are available at this stage but it appears to tolerate quite acidic soils, produces very well during cold winter conditions and is supposed to be quite drought tolerant. However, being preferentially grazed by stock, it will probably require rotational grazing to remain persistent.

Guidelines for Sowing Rates

The seed rate used will be largely influenced by the type of seedbed (non disturbed, cultivated or direct drilled), the planned use of the pasture (irrigated, dryland, weed or erosion control) and the soil fertility. Establishment percentages can vary from as low as 10% for surface sowing to 30% for cultivated or direct drilled situations.

Seed quality is also important for the successful establishment of a dense productive pasture. All seed offered for sale must have details of germination percentage and weed contamination. This should be investigated when purchasing seed.

Table 8.1 Expected establishment for the major introduced pasture species

PASTURE	SEEDS/KG (Approx)	SEED RATE RANGE (kg/ha)	PLANT ESTABLISHMENT RANGE (plants/m2)
GRASSES		Assuming a 25% establishment	
Cocksfoot	1,300,000	1-2	32-64
Consol lovegrass	4,000,000	0.5-1	50-100
Paspalum	650,000	2-4	32-64
Phalaris	650,000	2-4	32-64
Puccinellia	5,000,000	0.5-1	62-124
Rhodes Grass	2,800,000	1-2	70-140
Ryegrass (perennial)	530,000	6-8	80-160
Tall Fescue	420,000	8-10	60-100
Tall Wheat Grass	190,000	10-14	50-70
LEGUMES *			
Balansa clover	1,400,000	0.5-1	18-36
Berseem clover	326,000	3-5	25-41
Lotus	2,062,000	1-2	52-104
Lucerne	380,000	4-6	38-57
Persian Clover	1,456,000	1-2	36-72
Serradella (yellow)	196,000	4-6	20-30
Strawberry clover	766,000	1-2	19-38
Subterranean clover	120,000	2-6	12-18
White clover	1,600,000	0.5-1	20-40
Woolly pod vetch	25,000	5-10	3-6

* Establishment numbers for an annual species depend on the amount of hard seed in the ground.

NOTE: This table is only meant as a guide for assessing establishment. It does not imply that species should be sown at these rates in all situations (see insert for local sowing rates).

Points to Remember

- Legumes are an essential component of all developed pastures.
- Subterranean clover is the most widely adapted legume. Choose varieties after considering maturity, disease tolerance and paddock aspect.
- Cool season perennial grasses are well adapted to the region. Warm season species are only applicable to special situations.
- Perennial ryegrass seeding rates in pasture mixes should not be high.
- Introduced pasture species and sowing rates need to be determined after considering soil type/ fertility, seedbed, preparation, situation and seed quality.

Further Information

Brouwer D W, Ison R L, O'Reilly M V. (1994) *A Guide to Better Pastures In Temperate Climates,* NSW Agriculture/Wrightson Seeds 5th Edition

Approved Pasture Varieties for NSW. NSW Agriculture Booklet produced every two years.

Table 8.2 Key Features of Some Major Pasture Species

Species	Persistence	Ease of Establish-ment	Weed Control ability	Soil Erosion Control	Production				Waterlog Tolerance	Fertility Needs	Salinity Tolerance	Soil Acidity Tolerance	Minimum Annual Rainfall (mm)
					Summer	Autumn	Winter	Spring					
Phalaris	•••••	••	•••••	••••	•	•••	••	••••	•••••	❑•••••	•••	••	525
Per. Ryegrass	••	•••••	•	••	••	•••	••••	•••••	••••	•••••	•••	••••	700
Cocksfoot	•••	••••	••••	•••	❑••	••	••	••••	••	•	••	•••••	600
Tall Fescue	••	••	•••	•••	••••	•••	•••	••••	•••••	••	•••	••••	775
Lucerne	•••	•••	••	••	•••••	•••••	••	••••	•	•••	❑••	•	375
Sub clover	•••••	•••••	••	••		•	••••	••••	❑••	•••	•	•••	400
Serradella	❑•••••	••	••	••		•	•••	•••	••	•	•	❑•••••	400
White Clover	•	•••••	•	••	•••	••	••	•••	•••••	••	•	•••	700
Red Clover	•	••••	••	••	•••	••	••	•••	•••	••	•	•••	700
Strawberry Clover	•••	••	•	•	••	•	•	••	•••••	••	••••	••	600
Balansa Clover	•••••	••••	••	••		•	••	•••••	•••••	•••	•••	•••	400
Woolly Pod Vetch	•	•••••	••	•		•	•••	••••	•	•	•	•••••	500

The more dots the better value.

❑ Check on varietal differences. Highlighting has only been done where major varietal differences occur.

9. PASTURES FOR SPECIFIC SITUATIONS

Selecting the right pasture species and variety for individual paddocks is extremely important. The needs of the whole farm and its enterprises should be considered to determine the most suitable pasture with particular emphasis on filling the feed gaps. For example if feed is short in winter, then winter-active species should be considered to overcome this gap.

Effective rainfall and rainfall pattern, summer and winter temperatures and frequency of frosts will determine which species do best and these factors will vary from paddock to paddock depending on slope and aspect. Soil type and fertility will also determine what species perform best. A soil test of the paddock before sowing a new pasture is recommended to help you select the best species.

Drainage, depth and soil pH are the important soil considerations when selecting a species. Lucerne, for example, requires a deep, well-drained soil, which is less acidic. On the other hand most phalaris varieties are tolerant of waterlogging, but not of high soil acidity or low fertility.

Most introduced species such as ryegrass, tall fescue and phalaris as well as clovers and lucerne, require higher soil fertility for good production. Soils must be either naturally fertile or must have the essential nutrients supplied.

Due to the often large variation of soils over a paddock, it is worth considering fencing out different land classes and making separate paddocks. In this way pastures and management can be tailored to suit different areas.

Typical Pasture Mixes

Long-term Pasture

High rainfall (750 mm+)	
Phalaris	2 kg/ha
Tall Fescue	4–5 kg/ha
Sub Clover	4 kg/ha
White Clover	0.5–1 kg/ha

Moderate Rainfall (600 mm+)	
Phalaris	2 kg/ha
Cocksfoot	1.5 kg/ha
Sub clover	4–5 kg/ha
Optional	
Perennial ryegrass	0.5–1 kg/ha

Low Rainfall (<600 mm)	
Phalaris	2 kg/ha
Cocksfoot	2 kg/ha
Sub clover	4 kg/ha

Short-term Pasture (2-4 years)	
Perennial Ryegrass	6 kg/ha
Sub clover	4 kg/ha
White Clover	0.5 kg/ha
Optional	
Red clover	1–2 kg/ha

Lucerne Pure	
Dryland	4–6 kg/ha
Irrigated	8–12 kg/ha

Acid Soils (pH<4.5 $CaCl_2$)	
Cocksfoot	2 kg/ha
Tall Fescue	4 kg/ha
Sub clover	5 kg/ha
Optional	
Serradella	1–2 kg/ha

Wet areas	
Phalaris	2–3 kg/ha
Fescue	4–6 kg/ha
Strawberry clover	1 kg/ha
White clover	0.5 kg/ha
Sub clover	2–3 kg/ha
Optional	
Lotus	1–2 kg/ha
Paspalum	2–4 kg/ha

Salty areas	
Tall wheat grass	6–10 kg/ha
Puccinellia	2–4 kg/ha
Strawberry clover	2–3 kg/ha
White clover	0.5 kg/ha
Optional	
Lotus	1–2 kg/ha
Paspalum	2–4 kg/ha

Note: *The above mixes are to be used as a guide only. Sow higher rates where specific problems exist. Refer to your local insert for varieties and specific rates for your situation or alternatively contact your local NSW Agriculture agronomist.*

Points to Remember

- Select pasture species and varieties carefully for your paddock and livestock enterprise.
- Climatic factors, aspect, slope, soil type and fertility will determine which species do best.
- Fencing similar land types will allow pastures and management to be tailored to suit the different areas.

Phalaris is the best species to use in difficult sowing situations.

10. PASTURE ESTABLISHMENT

Successful pasture establishment is vital for later productivity and stability of sown pastures. When all cash and non-cash costs are considered, it currently (in the year 2000) costs about $200/ha to establish a pasture (plus $80–$150/ha if lime is required), so successful establishment is essential to capitalise on your investment.

The Decision to Sow

Before any pasture is sown, consider these questions: Is it necessary to sow new pasture and if so what pasture type is best suited to your soil and topography? Can the existing pasture be either improved/rejuvenated by tactical grazing and/or the use of selective herbicides, fertilisers etc? Can simple, less costly, non-destructive means such as broadcasting a legume and fertiliser increase production? Will the new pasture meet the livestock enterprise feed requirements? Will forage crops be a better alternative? Will your proposal comply with the *Native Vegetation Conservation Act 1997*?

The Planning Phase

If, after consideration, you decide to establish a new pasture, planning and attention to detail are essential to ensure that the money and time spent will produce the optimum result. To achieve successful establishment, there are three critical factors:

- ***absolute weed and pest control,***
- ***adequate soil moisture, and***
- ***accurate seed placement***

Sowing time has been found to be far less important than these three factors. We suggest you follow the eight step ***Prime Pasture Check List*** to ensure successful establishment. This is summarised now to help you ensure the three critical factors are achieved.

1. Assess and Plan Ahead: commence 12–18 months before to ensure selection of the most suitable species for the paddock and type of production. Soil tests from both the surface (0–10 cm) and deeper (20–30 cm) are recommended.

2. Year Before Weed/Pest Control: this step is vital and must commence in the previous spring for autumn/winter sowings. Spray fallowing is preferred to spray topping where windy spring weather can prevent spraying at the correct time to prevent annual seed set.

3. Pre-Sowing Grazing or Cultivation: integrates with step 2 to reduce trash and maximise weed germination before sowing.

4. Absolute Weed and Pest Control: ***the most important factor for success.*** Grass control herbicide options in new pastures are quite limited, so weed control in the year/s prior to establishment is essential.

5. Adequate Soil Moisture: moisture to a depth of 20 cm and at the surface ensures good germination and survival after sowing, even if dry conditions follow sowing. ***Do not sow into a dry seedbed.***

6. Accurate Seed Placement: place seed in contact with moist soil in a furrow. Aim for 5% of seed and fertiliser to be visible at the surface, thus ensuring seed is not buried too deeply.

7. Monitor Weeds And Pests: inspect 10–14 days after germination and then weekly.

8. First Grazing: graze when grasses are 10–15 cm tall provided the soil is moist and plants are well anchored. Grazing should aim to leave at least 5 cm (1000 kg DM/ha) pasture height. Remember that cattle are less selective than sheep. If it is dry, delay first grazing till after the pasture sets seed.

Sowing Time

On the tablelands, sowing after the autumn 'break' is traditional. However, temperate perennial pastures have been successfully sown on the tablelands from February through to September. Sowing should not occur until after weeds have germinated and been killed. This often means sowing in June or later.

While winter sowings will germinate slowly and there is sometimes increased risk of waterlogging, the advantages from achieving good weed control and soil moisture are far more important than sowing date. The problem of heavy frosts in winter causing fatal frost-lift can be a consideration in some very cold areas such as the Monaro especially on heavy soils and in cultivated seedbeds. Direct drill sowing largely avoids this problem.

Spring sowing in August/September tends to avoid these problems and also winter growing annual grass weed competition. In most of the region it has given good results and provides a good option for perennials. It is the preferred sowing time for lucerne.

Time of sowing is important for some species:

- Winter annuals such as subterranean clover must be sown in autumn-early winter as spring sowings are too late to allow seed set. They need to be broadcast sown the following autumn.

- Frost sensitive or sub-tropical species such as paspalum, Consol lovegrass, etc. require soil temperatures above 18°C and must be sown in late spring or early summer.

Seed Matters

1. Seed Quality and Sowing Rate

Seed costs are relatively small compared to the total cost of establishment, so don't be tempted to cut seed rates. ***Always use certified seed*** to ensure high germination and freedom from impurities (especially weeds).

Low seeding rates allow weeds to more readily invade and pasture density and production may never reach their potential. Increase seed rates in less favourable conditions e.g. broadcast sowings, rough seedbeds, acidic soils.

2. Inoculation of Legume Seed

Rhizobia are bacteria that allow legumes to fix and use atmospheric nitrogen for plant growth. Although rhizobia occur naturally in most soils, these may be less efficient than the strains available commercially as different legumes require specific inoculants to ensure effective nodulation. Inoculate with the correct strain of rhizobia. Lime coating of the seed is required in all soils with a pH ($CaCl_2$) below 5.5 to protect the inoculum bacteria from the acid soil and if seed contacts the fertiliser.

The trace element molybdenum is also required to enable the rhizobia to fix nitrogen and is thus important to ensure effective nodulation. It may be added to the lime used to limecoat the seed during inoculation or applied pre-mixed with the sowing fertiliser. Seed treatment is cost effective and ensures the molybdenum is where it is needed, close to the legume seed.

Survival of rhizobia outside soil is limited, so keep inoculated seed cool and out of sunlight and sow as soon as possible (preferably within two days) after treatment.

3. Other Seed Treatments

Treatment with a fungicide is recommended where 'damping-off' diseases such as pythium are anticipated, particularly with autumn/winter sowings. Fungicides can be applied during inoculation and will not injure rhizobia. Similarly, treatment of small surface sown seed (especially white clover and phalaris) to prevent ant theft will not harm rhizobia. Conversely, treatment of legume seed for earth mite control may be desirable, using registered insecticides, but these are highly toxic to rhizobia and must be applied 24 hours BEFORE inoculation. Seed must then be sown immediately after inoculation.

Your seed supplier using specialist equipment that should ensure a good product can carry out any or all of these seed treatments. Remember lime pelleted seed runs more slowly through the metering mechanisms of seed boxes, so calibrate the seeder using pelleted seed to ensure the correct sowing rate. Also, wait until the lime coating is dry before sowing, as damp seed will cause seed box blockages as will excess lime from poorly pelleted seed.

Sowing Issues

1. Seedbed Preparation

There are three ways to achieve a good seedbed.

- cultivation
- herbicides
- combinations of the above.

Heavy grazing alone will not produce a weed free seedbed and cannot be recommended as the sole means of seedbed preparation.

Heavy grazing is often used, especially in conjunction with herbicides. Spray topping or spray fallowing the previous spring is essential to reduce annual grass competition (from barley grass, vulpia etc.) no matter what method is used and should be followed up by grazing to reduce trash levels. Spray-grazing the previous winter is effective at reducing broadleaf weeds such as thistles, capeweed and Paterson's curse.

2. Sowing Depth

Pasture seeds are small and easily buried too deep. However, if only placed on the surface, the seed may be taken by seed harvesting ants or dry out before the seedling's root has entered the soil. For best germination, aim for good seed-to-soil contact with moist soil and coverage by loose soil of 1–2 cm.

3. Sowing Techniques

The sowing method used will be influenced by the erodibility of the soil, paddock topography, existing vegetation cover, and availability of appropriate machinery. There are several techniques that can be used.

Direct Drilling

This involves sowing seed into undisturbed soil following the use of a herbicide. It can be just as successful as sowing pasture into conventionally cultivated seedbeds. It is the method of choice in most situations, provided suitable sowing machinery is available (see notes later in this chapter). It provides greater flexibility in terms of:

- paddock use for grazing
- trafficability both before and after sowing

- more precise placement of seed
- reduced weed competition
- more precise control of sowing depth
- lower labour requirements

The use of narrow points combined with some simple, low cost modifications permit pastures to be successfully sown with most pasture drills and combines. There is also a range of specific pasture direct drill machinery.

Conventional Sowing

Aim to sow seed into a firm, friable and weed-free seedbed to provide seeds with good conditions for germination and growth. Cultivation has a role especially in heavy soils, where tussocky perennial grasses are present or the ground is very uneven or compacted due to pugging by stock and where erosion risk is minimal.

In many cases, a clean up crop before pasture establishment is useful. Oats, turnips, short-term and annual ryegrass are all suitable for this purpose and apart from providing valuable winter/spring feed, they can help break up heavy soils and reduce weed seed reserves.

There are two basic stages in preparing a conventional seedbed:

- Primary cultivation, preferably with tyned implements as they minimise inversion of the subsoil and break hard pans below the surface. However, where rocks would be brought to the surface, disc implements can be more appropriate. Be wary of one-way discs on shallow soils. Work across the slope, preferably on the contour to decrease the risk of run off and erosion.
- Secondary cultivations to break down clods, consolidate the seedbed and kill weeds. Make each working shallower than the previous one and depending on the soil type, use either an offset disc or heavy harrows. Beware of excessive cultivation, which can break down soil structure and lead to surface crusting. The number of workings can be reduced using a herbicide, instead of or with cultivation, for weed control.

Minimum Tillage

This technique involves limited cultivation with a tyned implement, usually in combination with one or more herbicide applications. These are used prior to the initial cultivation to improve the workability of the soil and speed up seedbed formation. Subsequent herbicide applications control germinating weeds.

Broadcast Sowing

This is only suitable for sowing certain legumes – no knockdown herbicide is used. Large areas of subterranean and white clover have been sown successfully throughout the tablelands using this method.

Broadcasting can be carried out by on-ground machinery such as fertiliser spreaders or by aircraft. Success depends on:

- cooler temperatures and good moisture to ensure germination and survival;
- minimal bulky standing top-growth but adequate plant litter (800–1000 kg DM/ha) to protect new seedlings;

Late April/May/June is normally the best time for broadcast sowing sub clover. Remember that once sub clover has reached the three leaf stage it is very tolerant of grazing which should occur to promote branching and hence maximise flowering and seed set.

Aerially applying herbicide is the first step when using the aerial-spray-sow technique.

Aerial Sowing

The aerial-spray-sow technique has been used to establish perennial pastures in the region for many years. The technique involves first applying herbicide by aircraft, and later the pasture seed and fertiliser. It is recommended where ground application methods are not possible and especially where land has been treated to remove, or is at risk from, weeds e.g. serrated tussock, St. John's wort, thistles etc.

It is the least reliable sowing method for perennial grasses and a costly technique, which must be thoroughly planned. Consider the weed spectrum, the need for pre-treatment of annual grasses (spray topping), grazing over summer to reduce bulk, ant theft of seed, slug damage and seedling diseases in the presence of heavy litter.

The best time to aerially sow is May/June but wait until there has been sufficient rain to provide 15 cm of damp soil — this may mean sowing in July or waiting until next year.

For best results when aerial sowing (or broadcast sowing white clover) :-

- treat all seeds with a registered insecticide to prevent theft by ants
- if possible stock sown areas at a high density for up to a week immediately after sowing to trample seed into the soil
- generally, spell until the following autumn, because aerial sown seedlings are not well anchored in the soil and are easily pulled out. This will allow the sown species to seed in their first year.

Prior to undertaking aerial-spray-sowing, the requirements of the Native Vegetation Conservation Act 1997 must be assessed.

Aerial sowing has been successfully used to sow into cultivated seedbeds, where waterlogging prevented the use of surface sowing machinery.

Sowing Warm Season Species

The sowing of warm season species applies mainly to perennial grasses. These, however have a limited role in most of the region due to inadequate summer rainfall. Where favourable conditions do occur, the following establishment procedure is appropriate:

- Plan to sow when soil moisture and soil temperature is appropriate to the species (late spring-early summer).
- Where summer weeds occur, weed control in the year(s) prior to sowing will be necessary.
- Perennial legumes such as lucerne, strawberry clover, white clover and lotus can be included.
- Sow seed into loose cultivated soil on the surface or just below and lightly harrow. Tiny seeds e.g. Consol lovegrass, or fluffy seed e.g. digit grass, are difficult to handle but seeds can be coated to increase their size and improve ease of metering. Otherwise it can be mixed with fertiliser, where pasture seed boxes are incapable of handling the seed. Once mixed with fertiliser, seed must be sown immediately, otherwise germination will be inhibited. Where a granulated fertiliser is used, mixing 4 kg of microfine lime with every 50 kg of fertiliser will distribute seed more evenly, and prevent seed settling to bottom of the seed box.
- Direct drilling has generally proven unsuccessful. However, it can be successful with heavy-duty tynes and spear points, sowing dry on clay soils and creating major subsoil disturbance. Such machinery often incorporates a press wheel. Substantial summer rains are then required for germination and the deep ripping ensures good moisture penetration.

Sowing and Machinery

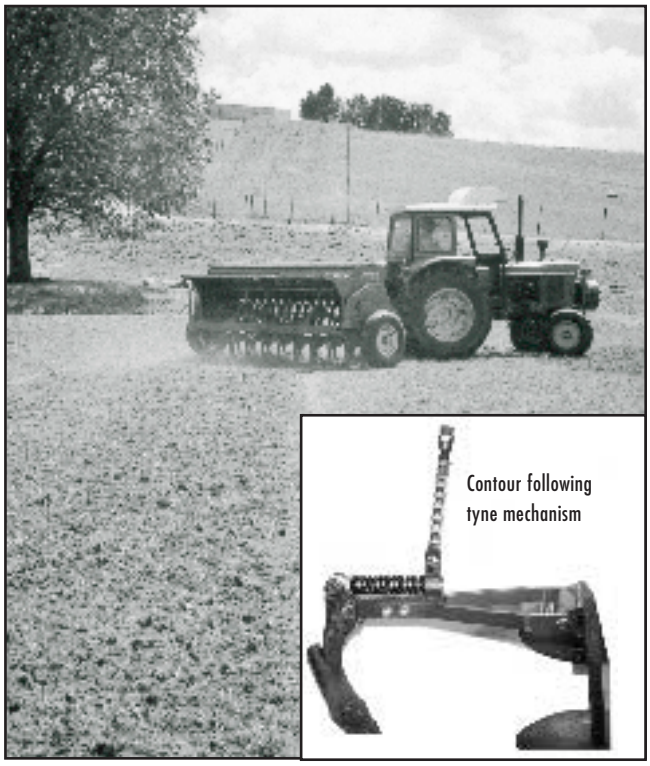
The aim of sowing is to place the pasture seeds in contact with moist soil and cover them with 0.5–1 cm of loose soil. It is very easy to sow seed too deeply, especially in cultivated seedbeds. Rolling before sowing can help where the seedbed is loose and fluffy and after sowing where moisture is marginal. However, beware of rolling post sowing on soils prone to crusting. Band seeders are preferred to achieve ideal seed placement in cultivated soil.

One advantage of direct drilling is that the seedbed is firm/fixed and so accurate seed placement is easier to achieve. While the machinery available for sowing are many and varied, drills can be either rigid frame machines or have a ground following ability on individual tynes. The latter include triple discs, single discs (and their conversions) and trailing tynes. They provide more precise sowing depth than rigid frame machines, such as most combines.

When sowing with a machine with a rigid frame some sowing points may scarcely scratch the surface while others, due to the uneven ground across the width of the seeder may be 3–4 cm deep. The aim in this case is for an average furrow depth of 2.5 cm but with the seed in each furrow only covered by 0.5–1 cm of loose soil.

Never use harrows or rollers when direct drilling otherwise seed will be buried. Single discs are generally not suitable for direct drilling unless converted, because they do not produce loose soil to cover the seed.

As a practical guide to correct direct drilling sowing depth aim for an average furrow depth equal to the first knuckle of your index finger. You should also be able to see 5–10% of the seed and fertiliser in the furrow but no more. Can't see any? Too much coverage!



Pasture seed placement is most accurate with seeders having contour following tynes.

Cropping and Pastures

Preparing For Pasture Sowing

Winter cereals are the most widely used crops for preparing paddocks for pasture sowing. Sowing a crop in the year(s) prior to establishing a new pasture can provide good preparation. It should only be considered an option if soil fertility and topography are suitable. On suitable soils, spring sown crops such as brassicas offer a good option achieving good control of winter weeds, as well as acting as a biofumigant against many soil borne diseases of seedling pasture. If winter cereals are used prior to a pasture phase, they should be grazed out in spring or cut for hay/silage, before the annual grasses seed. This will also minimise the potential for competition from a self-sown crop.

Cover Crops

Cover crops are not recommended when sowing perennial pastures. Increased competition for nutrients, soil moisture and the effects of shading, all contribute to reduced establishment and weakened growth of newly sown pastures.

If cover crops must be used, the following guidelines will help improve pasture establishment:

- Sow the cover crop in alternate rows.
- Reduce crop sowing rates to less than 15 kg/ha for cereals, accepting a subsequent crop yield reduction trade-off. (For cereals a 10–20% yield reduction, depending on soil fertility.)
- When using cereals, choose a grain only variety which has less potential to smother rather than a forage/grazing type. If a grazing crop is to be used, consider slow maturing brassicas, such as turnip or rape, sown at 0.25 to 0.5 kg/ha.
- If the pasture becomes overgrown by the cover crop, a quick concentrated graze will reduce competition and allow pasture to recover. Ensure that pasture plants are well anchored so they are not pulled out by grazing animals, and that 'bogging in' will not occur.

Points to Remember

- No matter what sowing method is used there are 3 critical factors—weeds and pests; soil moisture, and sowing depth.
- Follow the 8–step Prime Pasture checklist to ensure success.
- Direct drilling is as effective as conventional cultivation but offers greater flexibility.

Further Information

Prime Pasture (Establishment) Field Guide. (60 pages). Available direct from NSW Agriculture, PO Box 408, Queanbeyan 2620, Tel: (02) 6297 1861.

11. FERTILISERS FOR PASTURES

To achieve adequate pasture growth and production, most soils require fertilising to supply deficient nutrients.

Sowing Fertilisers

The seed supplies essential nutrients to enable seedling growth for several days after germination. However, seed borne nutrients are exhausted by about the tenth day and subsequent pasture growth is then influenced by the availability of nutrients in the soil.

Soil tests are a useful tool to assess soil nutrient status. Ideally sample soil at the same time of year to permit monitoring of change over time. For ease of sampling it is best done when the soil is moist in early spring or autumn. Avoid sampling in late spring when phosphorus, in particular, is mostly in the plant material that has grown. Always test prior to undertaking any new pasture development.

To maintain available soil nutrient levels for adequate pasture production, it is necessary to replace nutrients removed by livestock and harvested products. **Table 11.1** outlines the nutrients removed annually from a pasture by various enterprises/products.

Major Nutrients

Four main elements must be present in sufficient quantities:
nitrogen, phosphorus, potassium and sulphur.

Nitrogen (N)

Most soils are naturally deficient in nitrogen which is a principal component of protein and thus necessary for plant growth. Ideally, it is provided to pasture plants by legumes, via the nitrogen fixing bacteria on their roots. There are some occasions when nitrogen may need to be applied; e.g. when direct drill sowing pastures and when boosting production from existing pasture for hay or silage.

Phosphorus (P)

Most soils in the region with the exception of basalt derived soils are low in phosphorus and economic responses to applied phosphorus will occur.

Phosphorus is required for early root development and its availability influences plant growth potential and overall health. Adequate levels also stimulate flower and seed production. Even soils with a long history of applied phosphorus will benefit from its application at sowing.

A soil phosphorus level of 30 mg/kg (Colwell P test) will maintain good pasture production. To maintain this level, an annual application of 0.5 to1.0 kg of phosphorus per dse (dry sheep equivalent) is required, depending on the enterprise being run and the soil phosphorus status. **Table 11.2** provides a guide to recommended rates.

Table 11.1 Nutrients removed from pasture (kg/ha)

Production Type	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Sulphur (S)
5 t/ha pasture or lucerne hay	125	15	100	13
500 kg/ha of lamb or beef meat	15	4	1	4
50 kg/ha of wool	6	0.25	1	2
4 t/ha grain	80	18	20	6

Table 11.2 Recommended Phosphorus Rates for Sowing Pastures

Soil Phosphorus Status	Bray P Soil Test Value (mg/kg)	Colwell P Soil Test Value (mg/kg)	Phosphorus Rate (kg/ha of P)
Low	8 or less	15 or less	15-30
Medium	9-14	16-29	10-20
Adequate	15 or more	30 or more	10

Potassium (K)

Potassium is usually not limiting in pastures in most grazing systems except where long-term hay or silage production has occurred or where very heavy rates of lime are applied to light soils. Potassium helps legumes fix nitrogen and helps plants resist stress due to drought, disease and cold. Poor clover growth and particularly brown spots along the leaf margins can indicate a potassium deficiency.

Sulphur (S)

Sulphur availability is also linked to soil type with the basalt and granitic soils of the tablelands often sulphur deficient. Sulphur is particularly important for legumes. It is used by plants for protein formation and subsequently for wool growth.

Sulphur is found in two forms: either sulphate (e.g. gypsum) which is readily available to plants, or

elemental sulphur which is insoluble and slow to become available to plants. Single superphosphate contains approximately equal levels of both sulphur and phosphorus and so with regular supering, sulphur deficiencies are overcome. On high phosphorus basalt soils, gypsum is used to rectify low sulphur levels.

Other Elements

Calcium (Ca) and Magnesium (Mg)

Calcium is usually the most dominant cation in the soil and is rarely deficient for pasture growth. Likewise magnesium is an exchangeable cation and while it is rarely deficient, except in very sandy coastal soils, low levels can cause grass tetany in livestock.

Molybdenum (Mo)

Molybdenum is a trace element essential for the bacteria that fix nitrogen in the legume nodules and deficiencies are common in most tableland pastures. Mo must be applied to acidic soils once every 3–4 years. Molybdenum may be applied using Mo Super, or when sowing, it can be added to the lime used to lime pellet the legumes. Mo is more evenly distributed this way (on the seed) and is, therefore, more effective and recommended when sowing pastures.

Fifty grams (50 g) of elemental molybdenum is required per hectare on Mo deficient soils. Use either 75 g molybdenum trioxide (66% Mo) or 92 g ammonium molybdate (54% Mo). The Mo can be mixed either with the inoculant/glue solution or, dry with the liming material.

BEWARE! The fertiliser form of molybdenum, sodium molybdate, is toxic to rhizobia and must not be used when lime pelleting.

Sodium molybdate dissolves readily in cold water and can be sprayed directly on the pasture. It is 39% Mo so to apply 50g Mo/ha, mix 130 g in whatever amount of water your boomspray delivers per hectare.

Copper (Cu) and Boron (B) are trace elements that may be deficient in isolated cases. Copper may become deficient for animal health if excessive applications of molybdenum are applied. Boron is essential for good seed production of sub clover. In some cases these elements may become toxic e.g. boron may become toxic after high rates of lime have been applied.

Selenium (Se)

While not required for plant health, selenium is an important trace element for livestock health. Some tableland areas with a history of pasture improvement are notorious for selenium deficiency, particularly on the lighter, less fertile soils. Rural Lands Protection Board veterinarians are familiar with the local situation and can advise how best to overcome any problem.

Compound Fertilisers

A compound fertiliser (one containing nitrogen, phosphorus and sulphur or other elements) is the preferred fertiliser for pasture establishment as it provides establishing seedlings with essential nutrients for active growth.

For this reason, compound fertilisers are best used at sowing, with superphosphate most often used for subsequent pasture maintenance. **Table 11.3** compares the nutrients supplied by some commonly used fertilisers.

Table 11.3. Common fertiliser products

Product	N%	P%	S% (sulphate)	S% (elemental)	Ca%	K%
Starterfos (MAP)	10	22	2.3			
Granulock 15	15	12	11.7			
Legume Special	5.7	16	5.6	4.5	10	
DAP	18	20	2.0			
Single Super		8.6	11.0		20	
Pasture Starter	6.5	13.6		8.6		
Pasture Gold		13.8	4.4	12.7	15	
SF 45		5.5	7.0	35	12.7	
Muriate of Potash						50
Nitram	34					
Urea	46					

Fertiliser Maintenance Applications

Many factors influence the persistence and vigour of a pasture, but along with grazing management maintaining adequate levels of plant nutrients is the most important.

The present economic situation has most graziers looking at cutting costs and reducing or ceasing fertiliser applications to pastures is commonly considered.

What happens if fertiliser isn't applied for a while?

The rate of pasture production decline depends on the paddock's fertiliser history. The better the recent history and the higher the soil phosphorous level, the slower the decline in pasture production. Research has shown that in lower fertility situations pasture production can decline by 30% if you skip one year, 50% if you skip two years and 75% if you skip three years. Much of this production loss is reduced clover growth and so pasture quality declines too. As pastures lose vigour, weeds increase causing further pasture decline.

Priorities for Fertiliser Use

In most situations the current economics don't favour resumption of large scale 'whole farm' supering programs. Apply strategic applications of fertiliser to maximise pasture response and get the best value for

your fertiliser dollar. The following list is a guide to priorities for fertiliser application:

- Recently established pastures – they cost a lot to establish and will need top-dressing to allow them to develop and remain persistent. Most sown species will not persist unless adequately fertilised.
- Special purpose pastures – those used for fattening, weaning, lambing, hay or large numbers of stock e.g. close to shearing shed or yards.
- Older sown pastures with a low soil test value (see **Table 11.2**).
- Other pastures (including natives) with a low to moderate soil test, provided they contain legume.

Low priority areas for fertiliser application include:

- Paddocks with a long super history and high phosphorous levels
- Pastures dominated by weeds such as Paterson's curse, variegated thistle and vulpia
- Native pastures containing no legume

Liming Soil

Lime is not strictly a fertiliser but is used to supply calcium to counter soil acidity. In the same way that super is used to balance removal of P and S, lime can be used to balance the acidifying effect of taking plant products from the paddock.

Table 11.4 indicates the amount of lime needed to neutralise the acidification caused by removal of certain products.

Table 11.4 The amount of lime needed to neutralise acidification caused by produce removal

Produce removed	Lime requirement (kg/t of produce)
Perennial Pasture hay (phalaris, cocksfoot)	30
Lucerne hay	60-70
Cereal grain	5-10
Meat	17
Wool	14

When Should Phosphorus Be Applied?

A common fallacy concerning pasture topdressing in this region is that phosphorus fertiliser must be applied in autumn. This is not the case.

Research on subterranean clover pastures on the tablelands showed no differences in autumn clover growth where super was applied between the previous November and February. However, applications after February gave reduced clover production.

The problem with mid autumn and winter application is that it is often not there when the clover germinates and while soil temperatures and growth potential are relatively high. Also a greater proportion of fertiliser will be 'fixed' by the soil. 'Fixation' is where the phosphorus is converted by the soil into chemical states that are less accessible by plants. Fixation is greatest on acid soils and when soils are cold and wet.

Applying fertiliser at the end of the financial year may well be attractive for tax purposes but any advantage secured will be illusory if much of the phosphorus gets lost through fixation. The growth response of the pastures in autumn and winter is optimised by late spring or summer spreading.

Points to Remember

- For effective pasture establishment and growth, fertiliser will be required.
- Use soil tests to determine fertility status.
- Replace nutrients that are removed by the grazing system.

Further Information

Management of Profitable and Sustainable Pastures (1996) pp 43–50. NSW Agriculture publication. ISBN 0 7310 5732 5.

Liming raises soil pH enabling higher production from problem acid soils.

12. GRAZING MANAGEMENT

Grazing management can be a very powerful and cost effective tool to obtain the most from a pasture. It should be considered routinely like other management tools such as fertiliser or herbicide, and is often best used in conjunction with them.

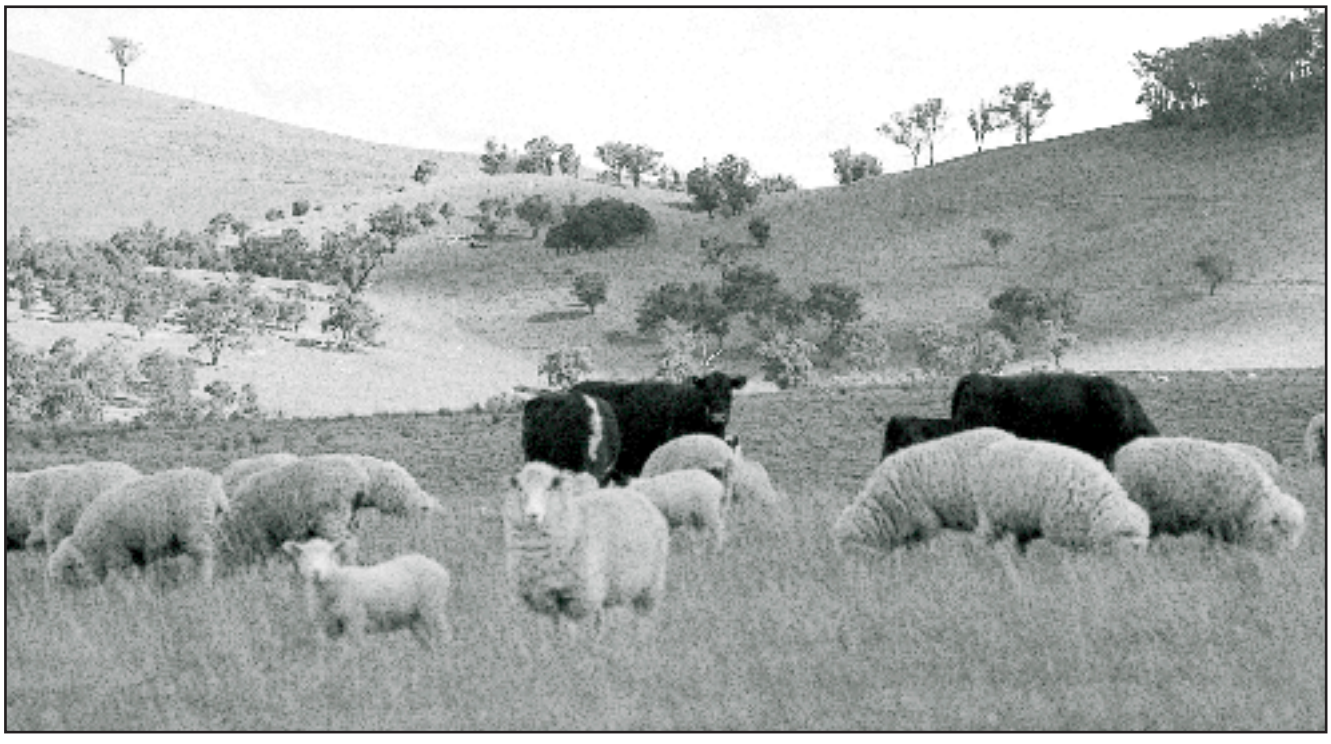
Good grazing management means you control what the stock eat and can thus:

- Optimise pasture growth and maximise feed quality
- Meet profitable livestock production and market targets
- Increase pasture utilisation and avoid selective, patch grazing
- Maintain adequate ground cover to prevent erosion and resist weed invasion
- Manipulate species balance to maintain an adequate level of legume.

Botanical Composition

This affects the amount and quality of herbage on offer and this in turn reflects animal production. Botanical composition of a pasture can be changed by grazing regimes and in particular:

- Stocking density and paddock size. The bigger the paddock and lower the stock density the more the stock are in control of what is eaten.
- Type of stock. Different grazing habits and dietary preferences of sheep or cattle can affect pasture composition – sheep graze very close to the ground and can be highly selective, while cattle are less selective and better able to graze tall growth.
- Class of stock. Dry stock, particularly wethers and to a lesser extent yearling heifers, can be forced to eat less palatable species or lower quality feed without penalty compared to young or lactating stock.
- Length and frequency of rests (if any). Most perennials benefit from a rest period after defoliation. The extreme example is lucerne which will die out if continuously grazed.
- Stage of plant growth when grazed. Strategic grazing such as crash grazing over flowering will reduce seed production of undesirable species as will tactical cutting for fodder conservation or even slashing
- Resting at critical times (e.g. until sub clover reaches the 3 leaf stage after the autumn break) can improve composition and persistence
- Allowing thin perennial pastures to seed down. This is particularly useful for large or fluffy seeded species such as ryegrass, fescue, cocksfoot and danthonia. It is less effective for phalaris because seed harvesting ants will remove large quantities of dry phalaris seed.



High density grazing for relatively short periods by large mobs of sheep and cattle increase pasture utilisation and reduce selective grazing.

Note: Grazing management of newly sown pastures is addressed in chapter 10 'Pasture Establishment.'

Seasonal Management of Established Sown Pastures

As many pasture species are sensitive to seasonal changes, management on a seasonal basis allows the producer to focus on the likely issues to address at a particular time. The following notes outline appropriate grazing strategies throughout the year.

Autumn

After the autumn 'break', both annual and perennial plants are regenerating from seed, stolons, crowns or tillers. Try to avoid heavy grazing at this time. In key paddocks such as those used for lambing, delay grazing sub clover until the 3–5 leaf stage to maximise winter production.

Winter

Over winter the challenge is to manage pastures to increase growth e.g. to maximise leaf area. Cold temperatures limit pasture growth during winter so use long rotations. Spelling of key paddocks such as those to be used for lambing or calving, is often required.

Spring

Control of pastures is critical in spring in order to maintain a good clover and perennial grass balance. However, it is the most difficult time to do this due to the bulk of feed produced. Ideally and where practical, keep early spring growth at about 5 or 15 cm high (1200 or 2500 kg DM/ha) for sheep or cattle respectively. This allows pasture to remain leafy and be of higher quality for longer. If there are not enough stock to control pasture growth just concentrate on some paddocks. Cutting hay, mowing or making silage in one or more paddocks is always an option while other paddocks may need to be allowed to run to head. Don't allow the same paddocks to run to head in consecutive years or sub clover seeding will be reduced. Sub clover produces the maximum number of flowers when grazed short (500–800 kg DM/ha) in early spring.

Summer

Pasture growth is limited by moisture stress. For winter active species, heat over 30ºC also limits growth. Avoid hard summer grazing and exposure of perennial plant crowns particularly when plants are moisture stressed. Such overgrazing may kill some species.

Graze perennial grass-annual legume pastures to about 1500 kg DM/ha (5–10 cm in height) in late summer/ early autumn to remove top growth and facilitate light penetration, germination and re-establishment of legumes. This strategy will also reduce allelopathic effects (where dry residues of some grasses release chemicals which adversely affect nearby plants). Allelopathic effects are worst if there has been no summer rain. Leached material from the dry, undecomposed feed inhibits the germination of new plants following the autumn break. Phalaris and vulpia inhibit growth and kill sub clover seedlings in this way.

Rotational Grazing

Some pasture species require particular grazing management for survival. For example lucerne requires rotational grazing in order to maintain plant numbers. As a broad guide, lucerne is best managed in a three to four paddock rotation whereby it is grazed for 10–14 days and spelled for six weeks. Chicory, a summer growing herb, also requires rotational grazing during its active growth period.

Managing Native Pastures

Our knowledge about how to best manage native grass based pastures is incomplete. Remember the more productive native pasture species respond to increased fertlity and particularly to legume nitrogen. However, there are two things to avoid — legume dominance especially in spring and development of excessive amounts of bare ground by overgrazing in summer. These situations are best assessed by regularly monitoring your paddocks.

Monitoring

Pasture composition is dynamic, fluctuating within and between years according to a whole range of factors including seasonal conditions and grazing/fertiliser management. Sound pasture management will aim to ***maintain ground cover and pasture stability***. It is essential to avoid instability over time through the loss of the perennial grass component.

Pasture composition usually varies both within and between paddocks so multiple inspection sites are required and once chosen, the same sites should be monitored each time. There are two critical times of the year to assess your native pastures for pasture stability (late winter and late summer). These can be used as a benchmark against future monitoring.

Late Winter

At this time of the year, ground cover should be close to 100% (droughts excepted) and all annual species clearly visible (e.g. annual legumes, grasses and broadleaved weeds). Annuals should be no more than 30–50% of the total pasture, while ensuring legumes are adequate (minimum 15–20% of the pasture).

Late Summer

The perennial grass component and the proportion of bare ground is easiest to estimate just prior to the autumn break. If the proportion of bare ground is steadily increasing from year to year this usually indicates loss of the perennial grass component. Monitoring is essential so that you can determine whether the changes occurring are beneficial or undesirable. For further information, see *Prime Pastures Management Guide*, *1996,* pp31–38.

NSW Agriculture offers a PROGRAZE course, for sheep and beef cattle producers, to develop skills in pasture and animal assessment and assist them in identifying ways to use these skills to improve their grazing management decisions. Contact your local NSW Agriculture office for details.

Points to Remember

- Grazing management is a cost-effective tool to obtain the most from a pasture.
- Good grazing management allows you to control what livestock eat and influence feed quality, pasture utilisation, ground cover and botanical composition.
- Objectives of various strategies will vary with seasons and species present.

Further Information

PROGRAZE Manual

Management of Profitable and Sustainable Pastures (1996). NSW Agriculture publication. ISBN 07310 5732 5.

*Grazing Management of Temperate Pastures: Literature Reviews and Grazing Guidelines for Major Species,*Technical Bulletin No. 47 - Edited by R.D. FitzGerald and G.M. Lodge (1997). NSW Agriculture.

13. MATCHING PASTURES AND LIVESTOCK REQUIREMENTS

Pastures are normally converted to dollars by grazing. One of the aims of farm management is to try to match seasonal pasture growth with the animal enterprise requirements.

Figure 13.1 shows the potential yearly pasture growth from a well fertilised pasture grown on the tablelands together with the requirements for four different livestock enterprises. These are fine wool wethers, autumn lambing 1st cross ewes, spring lambing 1st cross ewes and a beef cattle breeding enterprise. The stocking rates per hectare selected for the enterprises are 15, 9, 12 and 1.75 respectively to provide a similar total yearly consumption for each enterprise.

It can be seen that pasture production peaks in spring with a large surplus. But in summer and winter there is a deficit for all enterprises. Where this occurs, saving feed and carrying it forward into the times of shortage can make it up e.g. carrying feed over from autumn into winter by locking-up paddocks, rationing intake or providing supplementary feed.

The only other way, sometimes used in combination with one of the other strategies, is to allow animals to utilise their fat reserves and lose weight. This option is best suited to dry stock. It is common for the weight of wethers to fluctuate over the year representing changes in feed on offer i.e. wethers gain weight in spring but then lose this weight the following autumn/winter.

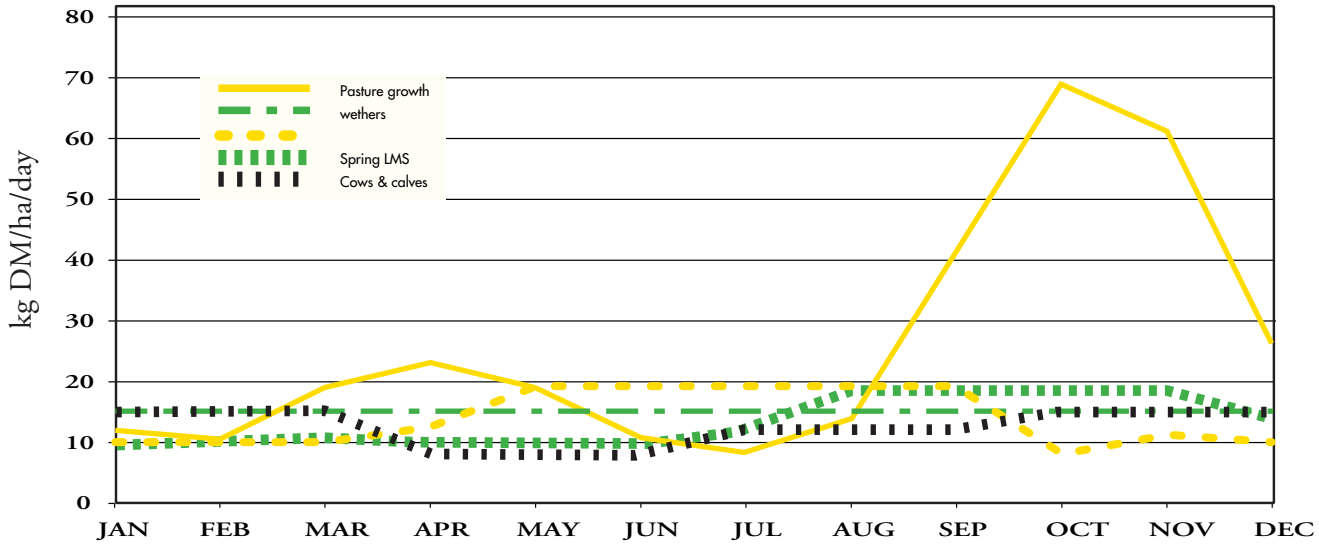
The wether enterprise, has the same feed requirement each month, resulting in a huge potential wastage in spring. Of the two lambing enterprises, the requirements of the spring lambing ewes more closely match the pasture feed supply, at a higher stocking rate, than that of the autumn lambing ewes.

Where there is a surplus this can either be saved as hay or silage, consumed by stock which fatten and then lose weight later when feed supply is deficient or remain as a store of low quality, dead standing feed in the paddock.

High quality feed is needed for different animal classes at different times of the year. This requires a mix of pasture types or forages over the property to meet these requirements. For example, young weaner sheep require high quality green feed to gain weight over summer. This green feed will not be supplied if all the pastures over the farm are the same and composed of winter growing/summer dormant annuals and perennials. A summer growing pasture or forage crop is required or there will be a need for grain supplements. Similarly, over winter there is often insufficient feed available for fattening of weaner cattle and this feed gap can be filled using a late summer sown, winter forage crop.

The PROGRAZE series of workshops, which cover this topic in more detail, are an invaluable aid in providing farmers with skills and knowledge which they can apply to their whole farm management.

Fig 13.1 Pasture growth and enterprise requirements



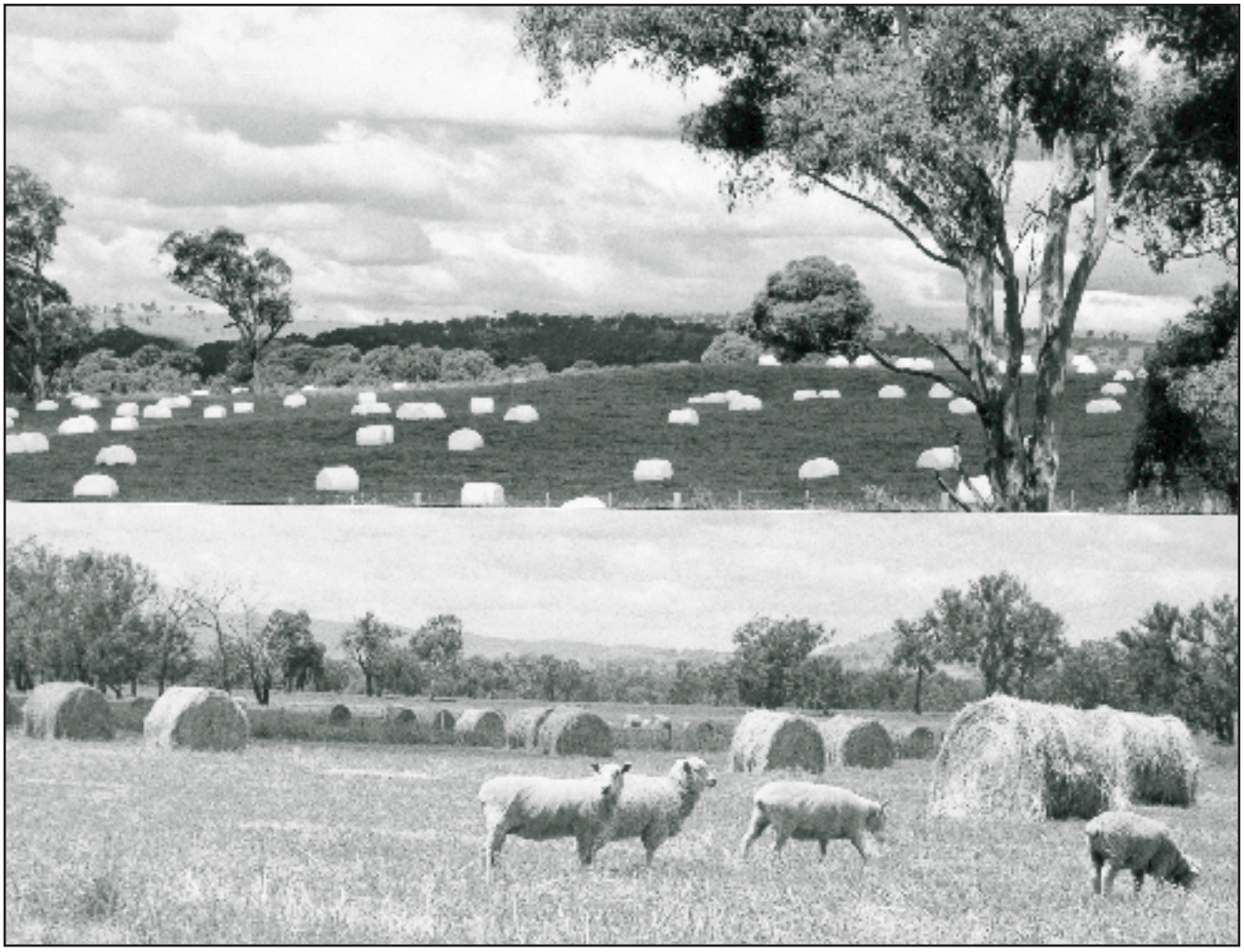
Animal Health Issues

With increasing stocking rates and higher quality pastures, the risk of livestock health problems may increase. Stock and production losses do sometimes occur but good management will minimise the risk of disorders occurring.

Occasionally, animal health disorders arise from particular plant species. For example, bloat risk is very high at certain times from high legume content pastures, pure lucerne can cause redgut in sheep, phalaris can cause staggers. These risks need to be fully understood when planning pasture sowing. Advice from a veterinarian and/or adviser should be sought when planning pasture improvement.

Further Information

Management of Profitable and Sustainable Pasture. (1996) pp 55–58. NSW Agriculture publication. ISBN 0 7310 5732 5.



Early cuts of hay or silage provide high quality regrowth for lambs.

14. WEED AND PEST CONTROL

The Importance of Weed Control

Weed competition is a major cause of pasture establishment failure and subsequently can cause a loss of pasture production. Pasture weed control is vital prior to sowing because there are few herbicide options in seedling pastures.

Once established a healthy perennial grass based pasture will control most weeds. However, there will always be some weeds in pastures and while some are invasive and take over considerable areas of the paddock e.g. thistles and Paterson's curse, many simply respond to the prevailing conditions and will decline naturally with different conditions.

Cultivation, cropping, slashing, herbicides, pasture manipulation and intensive grazing can all be effectively used to control weeds. Using one or a combination of these control methods in a planned program has the potential to increase pasture production and can greatly reduce weed infestations prior to and following pasture sowing.

Herbicides are an important tool in pasture weed control, but selection and correct use of the herbicide is crucial. ***Always read herbicide labels before use.***

Weed Control in Pastures

a. Before Establishment

- Good weed control is *essential* when establishing perennial grass pastures and/or lucerne, as seedlings are extremely susceptible to weed competition. Inspect paddocks at least twelve months before sowing to determine what weeds are likely to be problems and take effective control measures to reduce these anticipated weed infestations.
- Good seedbed preparation involves cultivation and/or herbicides to remove both grass and broadleaf weeds before sowing. Herbicide use prior to sowing is often more effective than cultivations.
- Some weeds can be more effectively controlled with less damage to the non-target pasture by combining sub lethal herbicide rates and grazing (the spray-graze technique).
- Difficult or hard to control weeds and/or heavy weed infestations may require control programs that start up to two years before the pasture sowing. There are three weed types in these situations:

1. **Perennial Grasses** - e.g. couch, bent grass, tussocks etc. Depending on the weed, control programs will vary and may require the use of combinations of herbicides and cultivation or multiple spraying. Seek correct identification and advice on the best control program for your situation.
2. **Annual Grasses** - such as ryegrass, barley grass, and vulpia can be effectively controlled by preventing seed set in the spring before sowing. This can be done by a chemical or mechanical fallow, or by spray topping. Hay, silage making, slashing or heavy grazing can also assist control by reducing seed set or removing seed. Cropping in conjunction with selective herbicides can effectively control annual ryegrass in most crops but not in oats.
3. **Broadleaf Weeds** - such as thistles, amsinckia, Paterson's curse and sorrel need to be reduced by herbicides, cropping and fallowing prior to pasture establishment. Spring sowing can be used to avoid competition from the winter growing annual weeds such as Paterson's curse which often have large reserves of hard seed in the soil despite pre-sowing control.

b. In Seedling Pastures

Grass/Clover Pastures

No herbicides are available to remove annual grass weeds from seedling grass/clover pastures. Fortunately broadleaf weeds, such as, thistles, wireweed, mustards, and Paterson's curse, can be selectively removed with various herbicides but these ***herbicides must be used while weeds are small.***

Lucerne

Pre-emergent herbicides are strongly recommended when sowing lucerne alone or with other legumes to control annual ryegrass and some broadleaf weeds.

Several herbicides can selectively control some grasses in seedling lucerne. Broadleaf weed control is similar to that for mixed pastures, with some additional herbicides.

c. In Established Pastures

Where possible weeds in established pastures should be managed and eaten rather than sprayed.

Weeds, in established pastures, can be classified into three broad types:

- **Survivors** - these colonise when fertility is low or declining. Examples are bent grass and onion grass. Increasing the fertility and at the same time the grazing pressure is often all that is required to bring them under control.
- **Competitors** - these often respond to high fertility e.g. thistles and barley grass. Manage the pasture to encourage competition from the perennial pasture. Selective fertilising to avoid sheep camps, rotational grazing, mob stocking, spray topping and spray grazing are techniques that can be employed.
- **Opportunists** - these colonise bare ground and so maintaining an adequate ground cover from a vigorous perennial pasture will usually keep these weeds under control. Sorrel, Paterson's curse and vulpia are common examples. The type of grazing animal can also result in either control or an increase in some weeds. In the case of Paterson's curse, cattle avoid grazing this weed whereas sheep tend to keep it under control.

With good management, slashing, hay or silage making at the right time and crash grazing can help control some weeds.

A well-established competitive grass/clover pasture should not initially have annual weed problems. If annual grasses start to increase in density they should be dealt with while the pasture is still strong. Techniques such as spray topping, winter cleaning or using soil residual herbicides can be effective.

However any of these techniques can temporarily reduce pasture production and affect the seed set of useful species such as clover and perennial ryegrass. These effects on the non-target pasture species can be greatly reduced if the pasture has a high level of soil nutrients or is topdressed at this time.

A number of herbicides will give effective and cheap control of most common broadleaf weeds in grass/clover pastures.

Using sub lethal rates of hormone herbicides followed by heavy grazing is an effective method of controlling some broadleaf weeds. This technique is referred to as 'spray grazing' and relies on increasing the palatability of the weeds. ***Warning: Take care with spray grazing as certain broadleaf weeds can be toxic to certain types of stock.***

Established Lucerne - control of annual grass and broadleaf weeds is commonly obtained using a mixture of a knockdown and residual herbicide in late winter. Specific weeds can be controlled using various herbicides for broadleaf or grass weeds.

Herbicide Resistance

Repeated use of the same herbicide or herbicides with the same mode of action increases the chance of herbicide resistance developing in weed populations. Good weed control programs should include the use of non-chemical control options and the full range of chemical options (different techniques and herbicide groups) where appropriate, to reduce the risk of herbicide resistance developing.

Control of Pasture Pests

As with weeds, insects and mite pests are a major cause of pasture establishment failure. In established pastures the necessity for control of these pests will depend on the pest population and level of damage occurring or likely to occur. Control of pests is often best achieved through a range of methods, such as grazing management, pesticides, cultivation and plant tolerance. Check latest integrated pest control techniques with your local NSW Agriculture agronomist.

Several pasture pests can affect pastures in the region. Some of the more common ones are listed below:

Red-legged earth mite suck sub clover leaves dry.

Earth Mites

Blue oat mite and red-legged earth mite commonly occur in mixed populations in the Tablelands. These tiny pests (the size of a pinhead), can destroy newly sown pastures and severely damage established pastures.

Mites hatch on autumn or early winter rains and in some years build up to plague proportions. They prefer dark conditions and are greatest in ungrazed pasture. Heavy grazing of adjacent paddocks or border spraying may be necessary to protect newly sown pastures from invasion.

Regular close inspections of establishing pastures, especially lucerne, should be made. Even bare fallows can be heavily infested with mites and plants can be killed as they emerge. In these situations plant damage is not obvious and is often not seen. Damage on mature plants is characterised by silvery or whitish appearance of the leaves.

Spraying is effective and cheap but not all registered chemicals control both mites. Specific products work better in certain situations e.g. those that are systemic work better on green plants, while others act well as bare ground sprays.

Spraying mites in spring before pasture sowing (along with spray fallowing) can greatly reduce potential mite problems the following year. Spraying just prior to pasture sowing will help to protect seedlings against mites. Seed can also be treated to protect against mites but if heavy infestations occur, seed treatment is often ineffective.

Aphids

Seedling lucerne can be severely damaged by spotted lucerne aphids and spraying may be necessary. Damage to sub clover by spotted alfalfa aphid is unlikely on most varieties.

Blue-green lucerne aphid can cause severe damage to sub clover and young lucerne. Populations of two or more aphids per growing point may require spraying.

Cutting or quick/heavy grazing of lucerne or clovers can also effectively reduce aphid populations and damage.

Sitona Weevil

These weevils eat the foliage and stems of lucerne and clovers. Heavy infestations can completely defoliate established plants and may kill seedlings or young plants. Spraying can be necessary.

Pasture Scarabs (cockchafers)

There are two types of scarabs – those that feed above ground on leaf and those that eat the roots. Pasture scarabs can develop into large infestations and cause serious damage especially to seedling pastures. Established phalaris is tolerant to root feeding scarab attack, most other introduced grasses are affected, especially ryegrass and cocksfoot. Control of the root feeding scarabs is difficult, as they cannot be controlled without cultivation. Insecticides can effectively control the leaf eating black-headed cockchafers.

White Fringed Weevil

The soil dwelling larvae of the white fringed weevil can seriously damage seedling and established lucerne plants. Control of this root feeding insect is difficult. The main means of control is cultivation and crop rotation for two years using cereals free of broadleaf plants and legumes.

Points to Remember

- Plan weed and pest control at least 12 months ahead of pasture sowing.
- Don't rely solely on herbicides/insecticides, investigate other pest control options.
- Seek the latest information on chemicals and always read the labels.

Further Information

See current editions of the NSW Agriculture booklets:
Weed Control in Lucerne and Pastures
Insect and Mite Control in Pastures
(both published biennially.)

15. ECONOMICS OF SOWING PASTURES

Sowing new pastures is of little value if livestock production is not increased to utilise the extra feed produced.

Is Sowing an Introduced Pasture Economic?

A quick way to answer this is to compare the cost of buying more land with the expected value from sowing pastures based on increased carrying capacity. For example, if land is worth $500/ha and runs 6 dse (dry sheep equivalents)/ha, the cost/dse area is $83. Thus, if it costs $200/ha to establish a perennial pasture, carrying capacity must rise by at least 2.5 dse/ha or, the pasture must have a special use and increase options in the whole farm context.

A more thorough way to evaluate the economics of sowing pastures is to prepare a cash flow development budget. This is simply a comparison of extra costs versus extra income, tabled for a number of years and taking account of varying stocking rates. Usually the stocking rate is zero in the first year, rising to the full rate by the fourth year. Interest charges on borrowed money, the cost to apply the necessary fertiliser and the cost of purchasing the extra stock must all be taken into account.

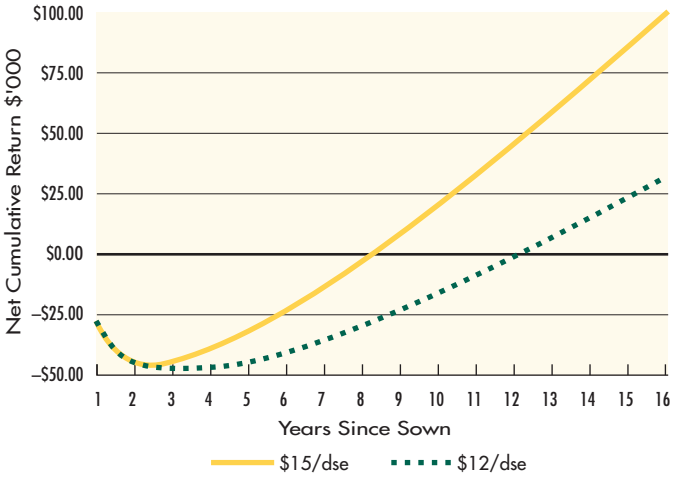
Table 15.1 is an example of this type of budget and is based on a gross margin of $15/dse.

Fig 15.1 summarises this and compares the result when the gross margin is only $12/dse.

Such budgets can't value other benefits such as protecting land from erosion, from invasion by noxious weeds or providing additional enterprise options that may result from sowing of pastures.

However, these data show the benefits from sowing pastures are long-term and that pastures need to persist for many years to be economic in their own right. In this example, provided stocking rate can be gradually increased from 5 to 9 dse/ha over the first three years, the net gain becomes positive after the eighth year. If gross margins are only $12/dse or a lower increase in carrying capacity is all that can be achieved, it will take 12 or more years to recover the costs.

Figure 15.1 Comparison of the Effects of Two Gross Margins on Returns from a Pasture Improvement Program



The Critical Factors

If as is common, pastures need to be re-sown after about 10 years, it may not be economic to sow pasture. The longer the pasture remains productive the greater the cumulative net return and the lower the pasture overhead costs.

What determines whether you can pay for pasture sowing is:

- the number of years a pasture can persist and remain productive, and
- your gross margin as it relates to carrying capacity, e.g. gross margin/dse. Unless this is about $15/dse and the stocking rate can be raised by 3–4 dse/ha or more, it won't pay.

Examine livestock husbandry aspects first if gross margins/dse are low.

Remember, under-grazing to achieve long-term persistence of pastures will reduce profits and can result in agronomic disadvantages such as the loss of legumes.

Economics of 'Sub and Super'

Broadcasting subterranean and sometimes white clover seed with superphosphate onto native pastures has been a successful method to non-destructively improve the amount and quality of feed and has been used since the 1950's. It is a relatively low cost technique and as pointed out in Chapter 7, several of the more desirable native perennial grasses will respond positively.

In this region where annual rainfall ranges from 600–850 mm, native grass based pastures, composed of red

Table 15.1 Pasture Development Budget

PASTURE SOWING FARM DEVELOPMENT BUDGET

Area of land (ha):	100	SR DSE/ha of base pasture (yr 0): 5
Cost of establishment per ha:	$200	SR DSE/ha of new pasture in yr 1: 7
extra cost of fertiliser per ha:	$20.00*	SR DSE/ha of new pasture in yr 2: 8
Gross margin per DSE:	$15.00	SR DSE/ha of new pasture in yr 3: 9
Purchase price of stock/DSE	$18.00	SR DSE/ha of new pasture after yr 3: 9
Interest on debt:	14.0%	* Based on a recommended fertiliser rate of 125 kg/ha every year.
Interest on credit:	4.0%	Normal fertiliser regime set at 125 kg/ha every third year.

Year:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	-500	700	800	900	900	900	900	900	900	900	900	900				
Pasture establishment	-$20,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pasture maintenance	$0	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000	-$2,000
Purchase stock	$0	-$12,600	-$1,800	-$1,800	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Extra profit	-$7,500	$10,500	$12,000	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500
FINANCIAL																
Interest	-$2,800	-$6,286	-$6,228	-$5,952	-$5,175	-$4,290	-$3,280	-$2,130	-$818	$194	$661	$1,148	$1,654	$2,180	$2,727	$3,296
BALANCE																
(advantage over no change)	-$30,300	-$40,686	-$38,714	-$34,966	-$28,641	-$21,431	-$13,211	-$3,841	$6,841	$18,535	$30,696	$43,344	$56,498	$70,178	$84,405	$99,201

*Based on a recommended fertiliser of 125 kg/ha every year compared to normal practice - 125 kg/ha only every third year.

grass or the year long green species, wallaby grass and microlaena, combined with annual legumes and grasses have the potential to carry 10–14 dse/ha with moderate levels of fertiliser.

The fertiliser required depends on the enterprise and the existing fertility level. For instance, 125 kg/ha per annum of single superphosphate was required for a fine-wool wether enterprise after 25 years without topdressing. After five years of this annual application, 125 kg/ha every second year now appears to be sufficient.

However, with a similar soil, pasture and fertiliser history a second cross prime lamb enterprise has required 250 kg/ha of single superphosphate every year. Assuming it costs $30/ha to purchase and spread 125 kg/ha of single superphosphate, including the use of Mo super every fourth year, then an increased carrying capacity greater than 2 dse/ha will be worthwhile. Experience suggests this is an easily achievable increase from most native pastures.

There is scant information comparing the economics of native pasture versus a conventionally sown perennial pasture. However, one comparison of the effects of several pasture development options on beef production and operating profit was carried out at Kamaruka in the Bega Valley from 1981–1985. An 80 hectare block of native pasture (mainly kangaroo grass and microlaena) was split into four paddocks and the following treatments imposed:

- Native pasture (no legume or fertiliser)
- Native pasture plus superphosphate (no legume)
- Native pasture plus superphosphate plus subterranean and while clovers; and
- A sown pasture based on phalaris, cocksfoot and clovers with fertiliser

After the five years of the trial, the native pasture with fertiliser and clover produced nearly as much cattle live-weight gain as the sown introduced pasture. However, it gave the highest net profit over the five years because the cost of the sown pasture was 50% greater than the 'sub and super' option.

Note: *the fertilised native pasture without a responsive legume produced little more beef than the unfertilised native pasture.*

Points to Remember

- Growing extra feed won't be profitable unless you run or fatten more stock.
- The longer a pasture persists and remains productive the more profitable the pasture development program will be.
- There is a need to balance grazing by stock for livestock production with grazing to ensure long-term pasture persistence.

16. CROPPING IN THE REGION

Cropping enterprises are generally limited in size owing to terrain, soil type, fertility and existing vegetation. The limited areas used for more intensive cropping are those with high fertility, deeper more arable soils, with a low risk of erosion, acidity and/or salinity hazards.

Winter crops are the major types grown. Mainstream summer crops are generally unsuitable, owing to the short growing season and low summer rainfall. Crops grown can be classified as:

Forage Crops

The major types grown include oats, spring and winter wheats, triticale, cereal rye and brassicas. Summer forages are minor components in the grazing systems but include brassicas, millet and forage sorghum.

Whether to sow a forage is largely influenced by seasonal 'gaps' in production of good quality pasture. The main feed deficit in the region occurs during winter due to low temperatures and lack of highly productive perennial pastures. Varieties of cereals are available that are dual purpose i.e. can be sown in early autumn for grazing, then 'locked up' in late winter for grain or hay.

Forage brassicas sown in spring offer good weed and root disease control for a following crop or pasture sowing. They provide an ideal seedbed for autumn/ winter direct drilling of the subsequent crop or pasture.

Grazing management for all forage crops should ensure that stock are removed when there is still sufficient leaf material remaining to allow quicker regrowth. Under very wet conditions stock should be removed to avoid crop and soil damage.

'Grain Only' Winter Crops

These crops consist mainly of oats, wheat, triticale, cereal rye and to a lesser extent canola, field peas, lupins and barley. They are occasionally used as cover crops for under-sown pasture (see cover crops in chapter 10) but crop seed rates need to be reduced.

'Grain Only' Summer Crops

This is mainly limited to buckwheat. Crops are generally sown after December rain.

Successful Cropping Practices

The decision to undertake any cropping enterprise must begin by assessing the type and quality of existing pasture (native or introduced) and if the crop is being grown as a forage after identifying where the 'feed gap' is.

Sustainable crop production on the tablelands is obtained via:

- Selection of suitable crop species/varieties. For example in many areas only acid tolerant species can be grown.
- Rotation of crops with pastures having a strong legume base.
- Direct drilling or minimum tillage of winter crops. **Note:** direct drilling of summer crops has a poor success record, with at least one cultivation required for successful crop establishment.

Generally the greatest challenges to cropping are soil acidity, fertility and susceptibility to erosion. Salinity is an emerging problem in many situations, and this hazard also needs to be carefully assessed.

Preparation for early sown winter crops or summer cropping should begin with a spring fallow to conserve moisture and soil nutrients. Judicious use of herbicides and/or livestock will control weeds, enabling cultivation to be kept to a minimum, thus preserving soil structure and minimising erosion. Cultivation, where necessary, should be done as close as possible to sowing, or if done earlier, the soil left in a 'rough' condition.

Annual grass weeds such as vulpia, barley grass, soft brome and ryegrass host root diseases that affect wheat and to a lesser extent, triticale and barley. Oats, canola, lupin, cowpea, forage brassicas, sorghum, millet and sudan grass hybrids are unaffected, with cereal rye rarely affected. Wheat, therefore, should not follow a 'grassy' pasture phase, unless annual grasses are removed in the winter prior to sowing. An eight month grass free fallow period is needed for root diseases to break down in the soil.

Points to Remember

- For successful cropping the following is essential:
  - (i) A fallow period
  - (ii) Correct choice of species/varieties
  - (iii) Rotation with good legume pasture
  - (iv) Minimal cultivation

Further Information

McRae, FJ. *Winter crop Variety Sowing Guide* (NSW Agriculture).
Gammie, RL. *Winter Cereal Management Guide* (NSW Agriculture).

GLOSSARY

Allelopathic
Chemical residues from mature plants or their residues that inhibit the growth of new seedlings.

Annuals
Those species that regenerate from seed each year and must set seed each year to regenerate (e.g. barley grass, subterranean clover).

Arable
Land suitable for cultivation.

Aspect
The compass direction that a slope faces

Biennial
Species that may last 2–3 years depending on seasonal conditions and management (e.g. red clover, some hybrid ryegrasses).

Botanical composition
Mixture of plant species in a pasture.

Cation exchange capacity
The capacity of the soil to hold and exchange positively charged minerals (cations) such as calcium, magnesium, potassium, sodium and aluminium. It is dependent on the amount of clay and organic matter present.

Degraded pastures
Pasture that has lost much of the perennial species and that has usually been invaded by annual species including weeds. Tends to have 30% or more bare ground at the end of summer.

Digestibility
A measure of the proportion of pasture or feed which, once consumed, can be used by the animal.

Dispersable soil
A soil with a high sodium content (also known as sodic soils) that is extremely prone to erosion by water.

dse
Dry Sheep Equivalent—is represented by amount of available pasture required to maintain an adult dry sheep at 45 kg live weight.

Gross margin
The income from an enterprise less the variable costs for the enterprise.

Herbage quality
Nutritive value of herbage, usually expressed as a digestibility percentage.

Introduced pastures
A pasture based on overseas species (e.g. phalaris, perennial ryegrass, white clover) that have been sown either in a prepared seedbed, direct drilled or aerially sown. Commonly called 'improved' pasture.

Legumes
Plants which have an ability to fix nitrogen in the soil. Clovers (*Trifolium* spp.) are the most common pasture legumes in this region. There are no native Australian clovers.

Native grasses
Grasses that occurred in Australia before European settlement.

Naturalised grasses
Grasses introduced from overseas and capable of distributing and regenerating themselves without human assistance (e.g. barley grass, couch grass, vulpia, bromes).

Natural capital resource
A term used to describe land capability potential in relation to climate, soils, topography, aspect and the plant species present.

Nitrate
The form of nitrogen present in the soil that is available for plants to use.

Non-arable
Land that cannot be safely cultivated.

Non-trafficable
Land that is too steep or rocky to drive over in a two-wheel drive vehicle.

Nutritive value
A measure of the nutrient status of a feed (energy, protein, minerals etc.)

Palatability
Relates to the preference (or priority) that grazing animals show when a range of species is offered. Palatability can vary according to locality, maturity, type of grazing animal and how much is available.

Panicle
A much branched seedhead.

Perennial
Those species that can live for many years (e.g. microlaena, phalaris, lucerne).

pH
A measure of a soils acidity or alkalinity. In this publication, all pH values are presented as those measured in calcium chloride ($CaCl_2$).

Photosynthesis
The production of organic material by plants using sunlight, carbon dioxide, water and soil minerals.

Radiation
The emission of rays from the sun to the earth's surface. Necessary for plant photosynthesis.

Rotational grazing
Stock are rotated across several paddocks with timeliness of moves based on a fixed time period or regrowth of pasture.

Rhizome
A root-like underground stem that can produce new roots and shoots.

Soil acidity
Acidity or alkalinity of a soil usually measured by pH($CaCl_2$).

Soil salinity
A build up of salt in the surface soil usually as a result of a rising water table and ground water seepage.

Slope/erodibility
Steepness of land and susceptibility to erosion.

Spikelet
That part of a seedhead that contains the seed.

Stolons
Prostrate shoots that take root at nodes or joints in contact with soil, forming a new plant.

Stoloniferous
Describes plants that have stolons.

Subsoil
The various layers of soil below the top soil.

Temperate species
Plants that inhabit parts of the earth between the tropical and polar regions.

Top soil
The surface layer of soil (usually 7–15 cm thick) that contains most of the organic matter and essential plant nutrients.

Trafficable land
That which, while non-arable can be driven over. This type of country can be direct drilled.

Warm season grasses
Includes all grasses that only grow over summer and are partially or totally winter dormant (e.g. *Themeda, Bothriochloa*).

Year-long green
A term used to describe those native perennial grasses that have the capacity to grow all year round given sufficient rainfall.