NSW DEPARTMENT OF
PRIMARY INDUSTRIES

‘The grazier’s guide to pastures’ - Readers’ Note

This document is part of a larger publication. The remaining parts and full version of the publication can be found at:

http://www.dpi.nsw.gov.au/agriculture/field/pastures/management/grazing-management/graziers-guide-pastures

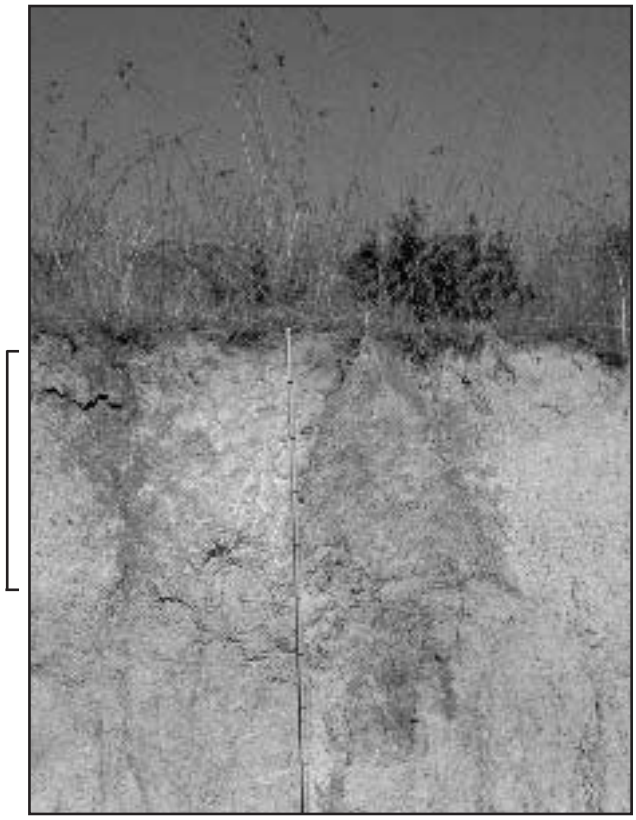
Updated versions of this document can also be found at the above web address.

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.

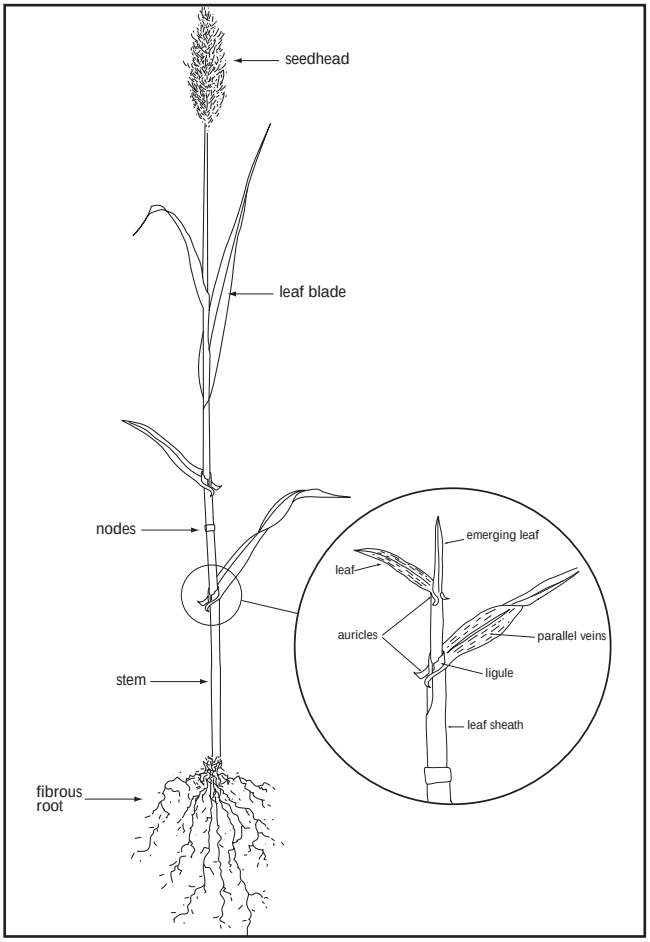
Grasses and Legumes

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



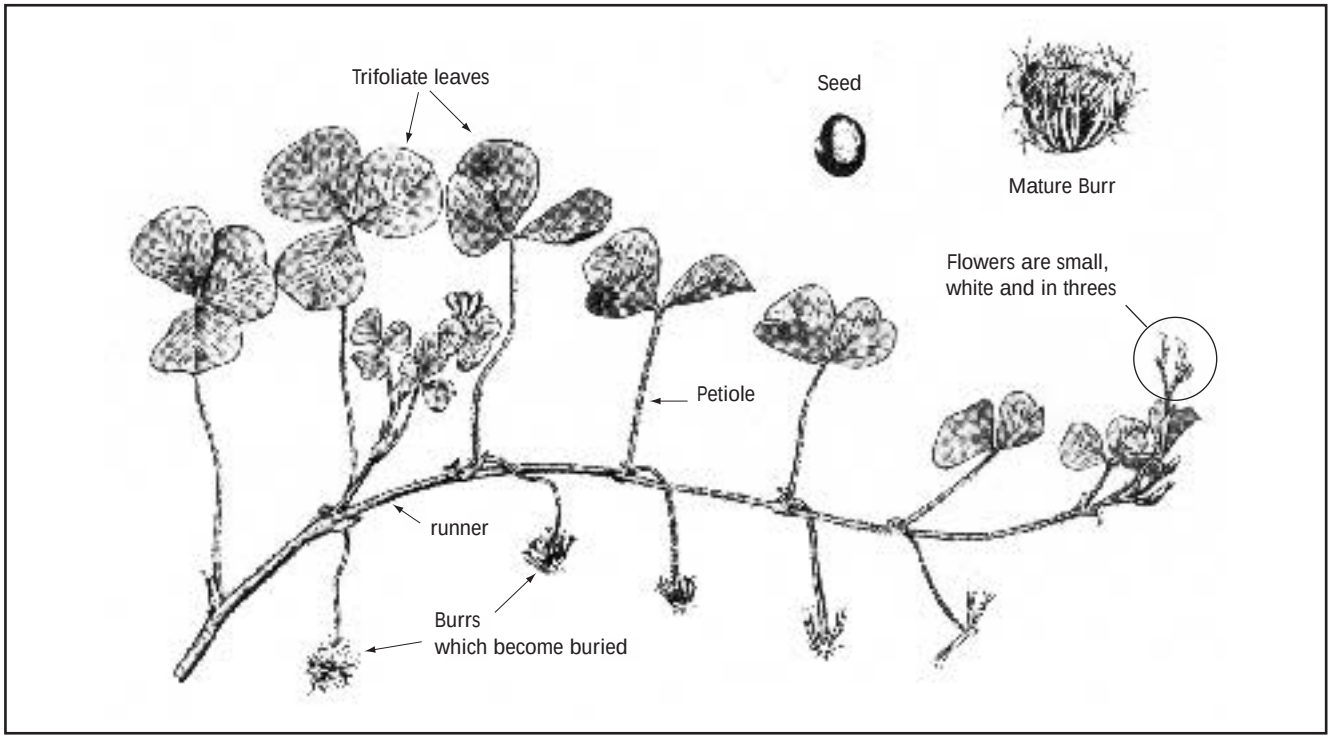
For further details about identifying specific pasture species refer to the notes in Chapter 7 of this publication for native and naturalised species and *Management of Profitable and Sustainable Pastures* (1996) pp 13–14 NSW Agriculture publication. ISBN 0 7310 5732 5. Available direct from NSW Agriculture,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

Figure 5.2 Stylised Sub Clover Showing Key Features



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.

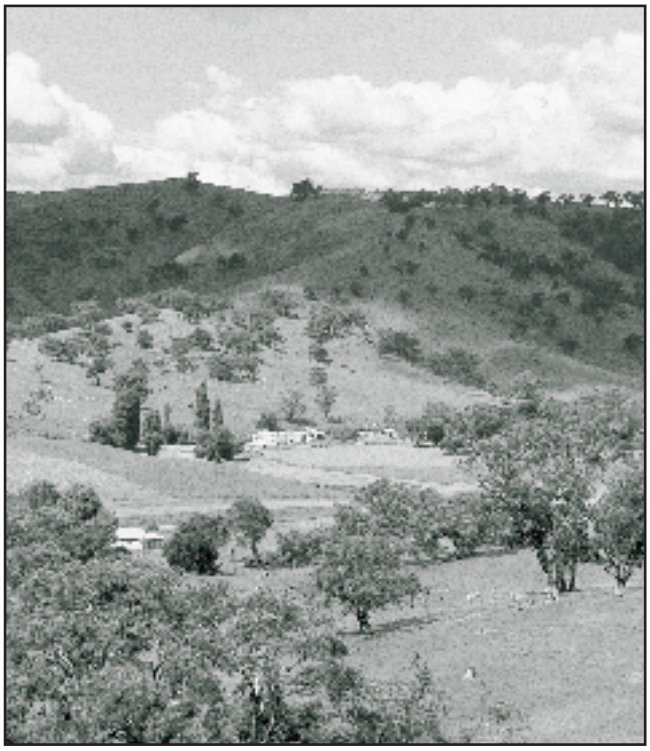
Some native pastures have a lower capacity for plant growth than introduced species (particularly during late autumn/winter/early spring) as well as marked seasonal production (often spring-summer). Feed quality declines quickly with maturity but especially when such species become frosted.

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 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.

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).

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; Y = Yearlong green native; A = Annual grass
NP = Naturalised perennial; (*) = Herbage value based on green leaf
H = high; M = medium; 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.

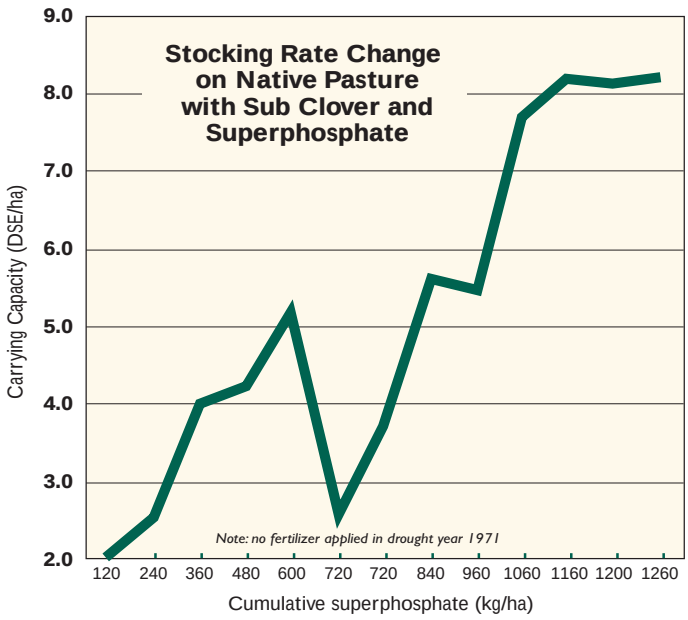
Pasture composition changed over time from mainly red grass to a diverse but stable mix of red grass, wallaby grass and microlaena plus annual legumes, annual grasses and some broadleaf weeds.

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.

Further Information

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Agnote *DPI 210, Yorkshire Fog, Friend or Foe?*

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Agfact P2.5.32. *Grasses - Native and Naturalised.*

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.