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Recognising and managing landscape and pasture diversity

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Abstract. Variability of landscapes, pasture and climate provides challenges and rewards for sound whole farm planning. Long term profit from grazing enterprises is based on keeping the perennial grass component and maintaining species diversity. Recognising the strengths and weaknesses of the natural resource base is essential for long term successful integration of development options. Alternative strategies are discussed in relation to key landscape features.

There is an incredible range of landscape and pasture diversity on the Central and Southern Tablelands of NSW. While this paper focuses on these areas, the management principles outlined will apply to a wider range of higher rainfall zones in NSW and north eastern Victoria. The diversity of soil type, aspect, topography and unpredictable and variable rainfall patterns presents a major challenge and reward for recognising and managing permanent pastures in a predominantly grazing environment.

I believe there are two fundamental principles that must be recognised and appreciated for developing stable and profitable livestock enterprises on a whole farm basis. These are:

- Sustainability is based on the need for maintaining perennial species and ground cover. This includes native perennial grasses, intro-duced or exotic perennial grasses and other vegetation based on native or introduced trees and shrubs.
- Maximum genetic livestock performance will only be achieved when there is green leaf on offer all year round (*i.e.* digestibilities above 65%.).

I have found it sobering reading the proceedings of the last three NSW Grassland Conferences. It appears that many producers are not able to main-tain the introduced perennial grass component of their sown pastures. Often, where the existing vegetation has been removed, there is no suitable long-term perennial grass as a replacement. It has been my observation and experience for nearly 40 years as an agronomist, that the only truly long-term introduced perennial grass that persists and maintains its productivity once established on the Tablelands has been Australian phalaris. However, even this grass suffers from droughts and stocking effects, and may decline in pastures over time (Hutchinson 1991; Figure 1).

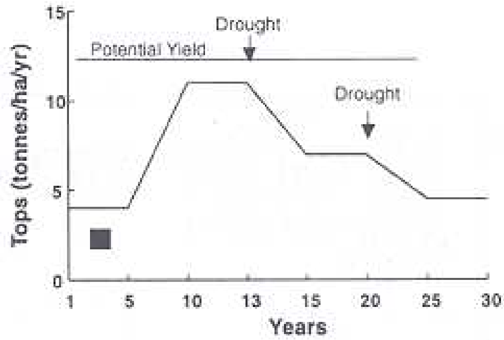


Figure 1. Cumulative drought effects on sown pasture production (from Hutchinson 1991). Note: Pasture = phalaris/clover, fertilised annually; Stocking rate = 30 dse/ha. Original yield of unfertilised native pasture shown as solid square.

Many surveys carried out during the last decade reveal that many farmers only expect their sown pastures based on introduced perennial grasses to last somewhere between 5 and 10 years (*e.g.* Archer *et al.* 1993). This questions the economics of a replacement approach for pasture development with introduced species under current cash flow returns in these environments (Patterson 1995). Development methods and management chosen should be based on the whole farm natural resources available and long term profitability. Five factors have a major influence on the ultimate selection:

- Existing pasture composition and production.
- Establishment reliability and costs.
- Persistence, particularly of the perennial grass component.
- Stocking rate increases which can be sustained over time.

- Gross margin return per dry sheep equivalent (dse) and per hectare.

Influences on development and management options

There are a number of critical climate and landscape features which can be easily recognised and have an important influence on options for development and management.

Rainfall

In south east Australia, rainfall varies between 500 and 1500 mm, though I believe the more critical components are variability, infiltration and evaporation. The most reliable period for the build up of soil moisture is during winter where, unfortunately, it provides the least amount of pasture growth. We very much depend on converting millimetres of rainfall into pasture growth in a notoriously unreliable autumn period or in the more reliable spring period.

It seems to me that most of our introduced species have incredible potential for growth in the spring, creating embarrassing surpluses of feed, but do very little to provide out of season green feed in the late spring/summer/early autumn period. Weaner nutrition is often a problem when summer active species are not part of pasture diversity, particularly where lucerne cannot be grown or does not persist.

During the last few years, I have listened to various speakers in different environments highlight the need to look at carrying capacity and productivity (dse) per mm of rainfall as an efficiency measure, with little or no qualification. This con-cerns me, as I believe this non-discriminatory approach is simplistic, and takes no account of other major resource or management limitations (*e.g.* soil acidity, low infiltration rates, highly erodible soils, large paddocks, *etc.*). Ignoring the impact of these restraints could well be providing misleading guidelines. In the south east of NSW, it has been estimated that run-off will vary from 2% to 12% of total rain, depending on soil type, topography, ground cover and rainfall pattern. To me, runoff is that portion of your annual rainfall that doesn't grow grass!

My understanding is that most of the research work undertaken to arrive at these productivity/rainfall relationships has been on small plots on mainly arable areas where there are no major environmental limitations (*i.e.* what I would call Class 1 and 2 arable areas). These probably represent less than 10% of our landscape. I have no argument with using this information where the natural resource base can cope with a high input system of fertiliser, introduced species and targeted management. However, I believe some of the information presented is inappropriate for semi-arable to non-arable areas, where there are other major resource limitations or limited management options (Hutchinson 1991).

Aspect interacts with rainfall, and has a major effect on the length of the growing season and pasture maturation in the spring, with exposed western slopes having major limitations. The true effect of rainfall is really reflected in the length of the pasture growing season, which is related to the diversity of species present across the range of landscapes that can respond to and utilise this rainfall whenever it falls throughout the year.

Soils

There is great variation in soil type on the Central and Southern Tablelands of NSW (*e.g.* Hird 1991). Generally speaking, the arable non-stony basalt areas, where rainfall is in excess of 500 mm, are well suited to high input pasture systems based on introduced species. Acidity problems are low to minimal, and these soils are fertile and have high rainfall infiltration rates. Unfortunately, less than 5% of the Central and Southern Tablelands is based on basalt soils. There is a large proportion of granite soil (about 30%) which is substantially lower in natural fertility than the basalt soils. Granite soils are rarely naturally strongly acid and, while some areas are highly erodible, they can be improved satisfactorily by sowing introduced species. Granite soils are tending to become more acid over time with pasture improvement and, in some areas, dryland salinity is occurring on the lower slopes and in discharge areas.

By far the most challenging and diverse soils are those of a sedimentary duplex nature (over 50% of the total area). Many of these soils are naturally acid (pH 4.5 or below in $CaCl_2$), and are located in semi-arable to non-arable environments. Frequently, these soils have acidity extending to a depth of 1 m or more.

Naturally-occurring acid soils. These areas can be easily identified by the native timber and pasture species present. Peppermint (*Eucalyptus dives* and *E. radiata*), white gum (*E. rossii*), she-oak (*Casuarina* spp.), ironbark (*E. crebra*) and sifton bush (*Cassinia* spp.) nearly always indicate strongly acid soils. Wiregrass (*Aristida ramosa*), weeping grass (*Microlaena stipoides*) and some wallaby grasses (*Danthonia* spp.) are also highly acid tolerant and, where they dominate, the likelihood is that soils will be acid (Simpson 1994). Kangaroo grass (*Themeda triandra*) and redgrass (*Bothriochloa macra*) tend not to grow in strongly acid soils and are usually associated with yellow (*E. mellio-dora*), white (*E. albens*) or apple (*E. bridgesiana*) box tree timber.

If acidity is only present in the surface 0 to 15 cm, then lime will correct this problem over time. Major limitations occur with development options (techniques and species selection) where acidity occurs to depth, since liming is relatively ineffective and doubtful economically, irrespective of the rate used. Pastures based on acid tolerant species are the only option and, where the year-long green perennial (acid tolerant) native grasses (*Microlaena* and *Danthonia*) are present, then non-destructive development options are preferred (Simpson 1994).

Induced acid soils. Recognising soils that have slowly acidified over time as a result of pasture improvement is not as easy as recognising naturally occurring acid soils. Perhaps the best visual cues are the gradual shift in species composition over time. The progressive increase in acid tolerant species (*e.g.* native grasses, cocksfoot), weed invas-ion (sorrel, flat weeds) away from other sown species (*e.g.* phalaris, lucerne), can indicate increasing acidity. However, it can also indicate declining soil fertility and overgrazing. Soil testing is the only reliable way to determine the significance of this pH shift. I believe we should be testing not only the 0 to 10 cm depth, but also 10 to 20 cm, so that better judgements can be made for pasture renovation strategies and species selection.

Slope and erodibility

Less than 10% of the high rainfall tableland areas are arable (*i.e.* where the risk of erosion from cultivation is minimal and cropping is an option). The balance is characterised by soil types which include highly erodible granites and sedimentary duplex soils where cultivation can pose a high erosion risk, particularly when carried out over summer-autumn when high intensity storms are likely. In these erodible environments, pasture establishment options are limited to surface sowing and/or direct drilling.

The rankings of pasture types in Table 1 relating to slope have been strongly influenced by the need to retain ground cover and, consequently, reduce erosion risk. Pasture persistence and the maintenance of ground cover should be the prime focus when considering development options on the steeper, more erodible acid soils. It is futile and self-defeating to destroy existing stands of native perennial grasses when they cannot be replaced by a pasture mixture which will be equally persistent over a wide range of seasonal conditions.

Some areas (*e.g.* steep, erodible, acid soils) may be best not developed at all, but lightly grazed or revegetated. Where other degradation problems exist (*e.g.* noxious weeds), then perhaps timber will be the most sustainable and economic enterprise in the long term, be it for weed control, harvesting of clean water, salinity reduction, or long term income from wood or carbon credits (when and if they eventuate) (Simpson 1998; Figure 2).

Wet and/or saline areas

From a pasture and livestock viewpoint, some of our most useful country lies in drainage lines, lower slopes or discharge areas. These may give the opportunity to extend the pasture growing season and produce green leaf into and over summer, although these areas can be challenging and difficult to develop and manage. Again, changes in species (both native and introduced) provide excellent indicators of these situations. Trees such as tea tree (*Melaleuca* spp.), black gum (*E. aggregata*), manna gum (*E. viminalis*) and swamp gum (*E. ovata*) indicate wet areas. A shift in pasture species to weeping grass, tussocky poa (*Poa labillardieri*), Yorkshire fog (*Holcus lanatus*), paspalum (*Paspalum dilatatum*) and rushes (*Juncus* spp.) also indicates wet areas.

Dryland salinity can be detected by changes in pasture composition. Cocksfoot and white and subterranean clover thin out and disappear as salinity levels increase, and are progressively replaced by more salt tolerant species including paspalum, York-

Table 1. Interactions between pasture type, soil factors and long term pasture productivity

Pasture type	Suitability to:						
	Slope[A]			Soil acidity		Soil fertility	
	Flat[B]	Undulating[C]	Steep[D]	Low[E]	High[F]	Low	High
Native (no fertiliser or legumes) Summer growing (*e.g.*, *Themeda, Bothriochloa, Microlaena*)	*	**	*****	*	*****	***	*
Native pasture plus legumes/ fertiliser(summer growing)	**	***	****	**	***	****	**
Native pasture plus legumes/ fertiliser(year long green natives, *e.g.*, *Danthonia, Microlaena*)	**	****	*****	***	*****	*****	****
Degraded introduced pasture dominated by annual grasses and broadleaf weeds	**	**	*	**	*	**	**
Introduced pasture with perennial grass plus fertiliser and legumes	*****	****	**	*****	**	****	*****

Note: More *** indicates better performance over time. [A]Related to persistence and production of perennial pasture, ground cover and steepness of land. [B]Arable. [C]Arable by direct drilling. [D]Can only be improved by aerial means. [E]Low acidity - pH above 5.0 $CaCl_2$ test. [F]High acidity - pH below 4.5 both top and sub soil. Aluminium above 15% of total cations.

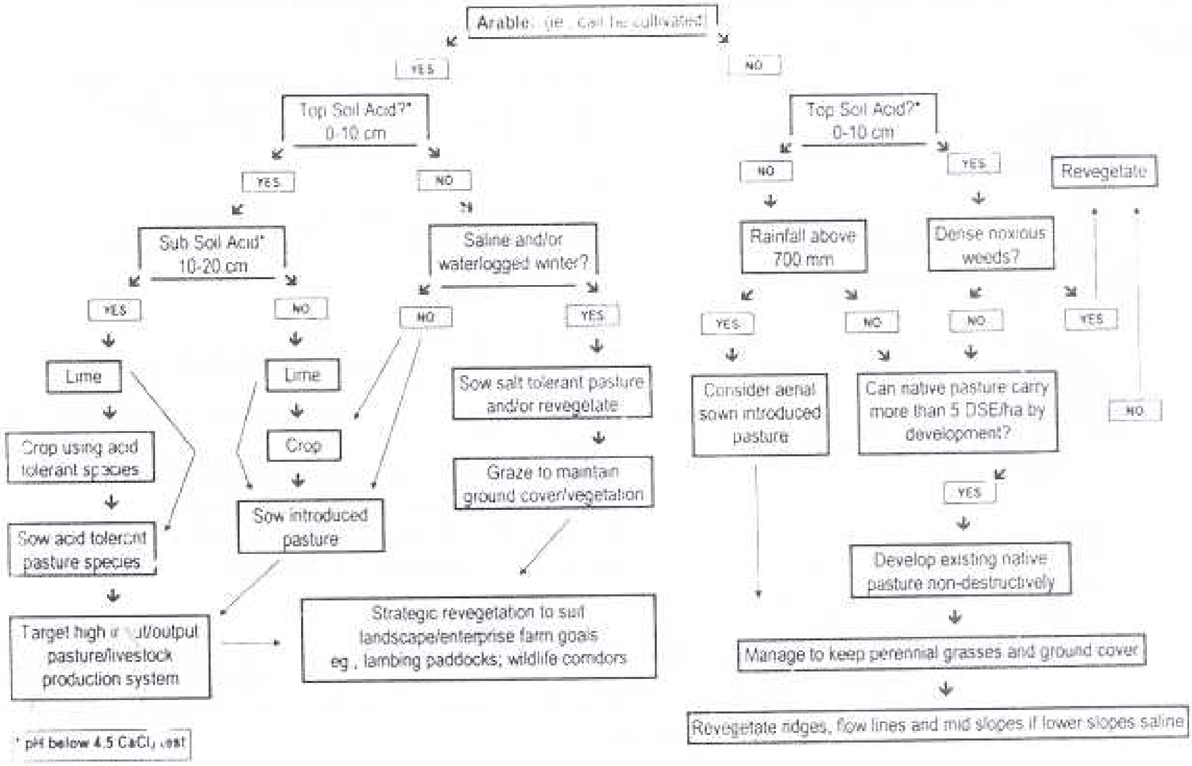


Figure 2. Influence of major landscape features on trees *versus* pastures

shire fog, dryland couch (*Cynodon dactylon*) and sea barley grass (*Hordeum geniculatum*).

Land class

The wise manager knows the features of his natural capital resource, particularly those features which he can modify, and those that he can't (*e.g.* subsoil acidity, aspect, slope, *etc.*). Selecting and/or maintaining those species that match soil type and enterprise needs and will also provide ground cover is essential for long term sustainable profit from pastures.

Various organisations have different methods for classifying land capability, although they all attempt to rank the ability of the natural capital resource to sustain production over time. The various land classes used by NSW Agriculture and their features and options are shown in Table 2 (Simpson and Langford 1996).

High input/high output systems with current technology options are best suited to Class 1 and 2 country for both pastures and crops. Increasingly, as you move into Class 3 country, the balance between agricultural productivity and conservation goals becomes more important and difficult to achieve. If Australian phalaris cannot be reliably established and managed as the basis of introduced pastures, then other introduced perennial grasses have to be used (*e.g.* ryegrass, fescue, cocksfoot), but are unlikely to persist for longer than 10 years.

The major focus in Class 4 country is to maintain ground cover. Development and manage-ment strategies could consider encouraging the year -long green native perennial grasses *Microlaena* and *Danthonia*. The most economically and environ-mentally sustainable method for increasing the productivity of native grass pastures in non-arable hill country is non-destructive pasture development and management. This strategy is essential if the soil is acid (pH below 4.5 in $CaCl_2$).

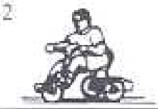
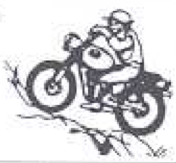
Noxious plants

The most invasive and widespread noxious plant in the south east is serrated tussock (*Nassella trichotoma*). In non-arable areas on low fertility acid soils, pasture management must be based on "keeping clean country clean". This is a real challenge, but if not pursued in these areas, this species will ultimately dominate all pasture types, and revegetation may be the only feasible and long-term economic option (Roberts 1997; Figure 2).

Balancing pasture type and landscape

There are five major factors which determine whether native, modified native or introduced perennial grass-based pastures are likely to best fit. These are land class, slope/erodibility, soil acidity, aspect and drought persistence. Table 1 compares various pasture types in relation to these factors, and Table 3 outlines the tolerance of individual pasture species to drought, acidity and grazing, their herbage values (based on green leaf) and their responses to fertility (Simpson and Langford 1996).

Table 2. Features of NSW Agriculture land classes, and broad options for development and management.

Land Class[A]	Key Features	Options
1-2 	Arable High fertility Minimal erosion risk Non-acid (pH above 5[B])	Unlimited for both pasture and crop production in seasons when the amount and distribution of rainfall is adequate. High input/high output systems should work well.
3 	Semi arable Lower natural fertility Moderate acidity (pH 4.5-5[B]) Moderate erosion risk Lower to middle slopes	Irregular cropping. Ground cover and pasture persistence important. Maintain native pastures or non-destructively develop (*e.g.* direct drill).
4 	Non arable Infertile shallow soils Acidic (pH below 4.5[B]) Moderate to high erosion risk Middle to upper slopes	Only suitable for permanent pasture. Generally hostile environment for most introduced perennial grasses. Best suited to low input system based on year long green native grasses. Manage to maintain pasture stability and ground cover.
5 	Non arable Infertile shallow soils Acidic (pH below 4.5[B]) Usually highly erodible Steep upper slopes	Leave undisturbed to either timber or revegetate. Lightly graze to maintain existing native pasture/ground cover. Retire from agriculture for conservation

NOTES: [A] Land classes as per NSW Agriculture: Class 1 - Arable land suitable for intensive cultivation; Class 2 - Arable land suitable for regular cultivation for crops but not suited to continuous cultivation; Class 3 - Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture; Class 4 - Land suitable for grazing but not for cultivation; Class 5 - Land unsuitable for agriculture or at best suited to light grazing. [B] pH measured by $CaCl_2$ test.

Sustainability of permanent pastures and landscapes in south east Australia is directly linked to maintaining the perennial grass component and maintaining ground cover. Trying to associate short term productivity (*e.g.* stocking rate per hectare or short-term enterprise gross margins) to disguise and prolong the need for industry structural reform is naïve and ignores the need for a holistic whole farm approach that is harmonious to the natural resource base. This latter approach should be compatible with the broad aims of catchment management. It is essential that development and management strategies ensure that ***all*** areas of a property are used in the most effective and sustainable way. There are five broad based pasture development strategies or situations which may be considered:

- 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.
- Degraded pastures based on introduced species plus weeds, with low fertiliser and stock manage-ment inputs.
- Low input systems with lower production potential, based on maintaining native perennial grasses (*e.g. Danthonia, Microlaena, Poa, Stipa, Bothriochloa*) in association with introduced annual legumes and limited fertiliser applications.
- Maintaining a pasture primarily consisting of native perennial grasses (*e.g. Bothriochloa, Themeda, Danthonia, Microlaena*) with no fertiliser or legume input.
- Using commercial native grass seed (when available) to modify or redevelop pastures. For example, replacing wire grass or annuals with year-long green native grasses (*e.g. Danthonia, Microlaena*).

All of these approaches have strengths and weaknesses from an agronomic, livestock, economic and conservation viewpoint. However, most tableland farms have a diversity of soil types, aspect, pasture types and enterprise needs which allow a wide range of pasture and livestock management options to be utilised. Development and management decisions in individual paddocks should not be made in isolation. Whole farm planning needs to consider all the factors as a total package and requires management for sustained profitability.

Surveys on the Central and Southern Tablelands have shown that many pastures classified as "improved" have a significant component of native grasses contributing to the productivity of the pasture (*e.g.* Garden *et al.* 1993). These surveys also showed that native pastures with a history of "sub and super" were carrying on average 80% of the stocking rate of a sown pasture based on introduced grasses (7 *versus* 9 dse/ha - Munnich *et al.* 1991). These native grass-based pastures were, on average, located in soils nearly 10 times more acid than the introduced pastures (pH 4.1 *vs* 4.9 in $CaCl_2$), and had only received one third of the fertiliser inputs. When comparing different pastures the following points need to be considered:

- ability to provide herbage of a quality which sat-

Table 3. Major features of some common native and introduced perennial grasses

Common name	Botanical name	Drought tolerance	Acid soil tolerance	Grazing tolerance	Herbage value[A]	Fertility response
Summer growing[B]						
Kangaroo grass	*Themeda triandra*	H	L-M	L	L-M	L
Redgrass	*Bothriochloa macra*	H	L-M	H	M	M
Wiregrass	*Aristida ramosa*	H	H	L	L	L
Year-long green[B]						
Wallaby grass	*Danthonia* spp.	H	M-H[C]	H	M-H	M-H
Weeping grass	*Microlaena stipoides*	H	H	H	M-H	H
Tussocky Poa	*Poa* spp.	M-H	M-H	M-H	L-M	M-H
Spear grass	*Stipa* spp.	M-H	M-H	M-H	L-M	L-M
Introduced[D]						
Phalaris	*Phalaris aquatica*	H	L	H	H	H
Cocksfoot	*Dactylis glomerata*	M	H	H	M-H	M
Perennial ryegrass	*Lolium perenne*	L-M	M-H	H	H	H
Fescue	*Festuca arundinacea*	M	H	M-H	M-H	H

[A] Herbage value based on green leaf; [B] Native; [C] Acid tolerance depends on species; [D] Rankings will vary according to variety and location.

isfies livestock requirements throughout the year.

- suitability to soil type (acidity, fertility, drainage, *etc.*).
- persistence for ground cover, erosion control and profit.

Looking to the future

Trying to manage climate and landscape diversity is challenging. The limited opportunities for enterprise diversification away from grazing mean that, for most situations, we have to make better use of what we've got. We also need to be aware of the realities of cash flow and long term pasture stability (PROGRAZE and Farming For The Future are two programs with this aim).

Longer term, whole farm and catchment issues (*e.g.* harvesting clean water, dryland salinity, acidity, pasture degradation, noxious weed invasion, etc.) are not going to go away. While some of these issues can be economically and technically solved now on-farm, others are beyond the resources and cash flow of many existing landholders. Retiring land from grazing, adopting low input/low output pasture management strategies, revegetation programs, topdressing lime on acid tolerant pastures to maintain ground cover, are all current options, though I cannot see their widespread adoption within the current industry structure and cash flow.

Integrated policies and programs based on cost sharing or incentive schemes will have to be developed and implemented if we are to move forward (Crosthwaite and Malcolm 1999). As an example, revegetation programs could be stimulated by creating a carbon tax credit scheme, and the off-farm benefits that flow for catchment management (*e.g.* salinity, clean water) estimated and used as a basis to provide discounted loans or grants to landholders. Catchment management committees could be provided with development capital through an environmental tax on vehicles for targeted regional revegetation programs.

The Murray-Darling Basin concept of cost sharing is one I believe in strongly, and the sooner key issues are identified and strategies developed, the better organisations like the Grassland Society can have a key role to play in community education and adoption of sustainable grassland management practices. It is my opinion that, historically, pasture development has been primarily based on replace-ment of existing pastures with high input/high output systems, and the landscape balance has been lost. In our non-arable, low fertility, acid soil areas, such strategies will not be sustainable. Landscape and climatic diversity must be better understood, and development and management strategies that enable and maintain permanent ground cover and species diversity that is harmonious to the natural resource base pursued (Alexander 1996; Young 1998; Johnston *et al.* 1999).

I am reminded of a comment made to me by a producer at a field day some years ago. He said, "It seems that I spend about half my time killing plants that germinate, grow, multiply and successfully persist or regenerate, and the other half trying to replace them with plants that won't". I have been pondering the impact of this statement for a long time and it should make us all reflect on the cause and effect of what we are doing, where we are going and where we would like to be with our landscapes in the 21st century - a challenge to us all!

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