Pastures for Protection & Production on marginal cropping lands

Queensland Murray Darling Committee Inc.

Queensland Government

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The technical content of this book is based on the Proceedings of the
7th Australian Tropical Pastures Conference
held in Dalby in April 2007.

Additional content has been taken from the Proceedings of the
8th Australian Tropical Pastures Conference
held in Goondiwindi in March 2009.

Both conferences were organised by the
Tropical Grassland Society of Australia Inc.

TROPICAL GRASSLAND SOCIETY OF AUSTRALIA INC

Front cover

Heifers and steers being backgrounded on a cell-grazed pasture of Bambatsi panic and Queensland bluegrass on the Ten Mile Cattle Co. property of Balandry, north of Goondiwindi.

This publication has been compiled by Ian Partridge of Regional Development (South Region), Queensland Primary Industries and Fisheries.

On 26 March 2009, the Department of Primary Industries and Fisheries was amalgamated with other government departments to form the Department of Employment, Economic Development and Innovation.

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Foreword

The condition of soils on many farming lands of southern Queensland has declined after decades under cropping. Soil organic matter has been lost, and the fertility and structure of the soil has dropped. The surface layers of many soils have become hard setting and seal so that rainfall does not infiltrate quickly; the water that drives crop growth flows off, taking with it the best top soil. Increasing inputs of fertiliser are needed to maintain crop yields and enormous quantities of soil are being lost. Cropping becomes even more risky, especially on the more marginal soils with low and highly variable rainfall.

The effects are felt at the farm level and at the catchment level. On the farm, landholders are having difficulty in justifying the increasing levels of inputs required to maintain production, and economic returns are decreasing. Over the whole catchment of the northern Murray-Darling river system, river flow is becoming more erratic, and water quality is declining with increasing turbidity from sediment.

The Queensland Murray-Darling Committee (QMDC) is encouraging farmers to return large areas of marginal cropping soils to permanent pasture—both to restore soil health and to develop a more sustainable farming system.

This publication summarises the results of decades of research in the sciences of pastures and soil conservation. These results were presented at Tropical Pasture Conferences organised by the Tropical Grassland Society of Australia in 2007 and 2009. The information was first published in scientific papers as conference proceedings; this book presents the information in an easy-to-read style more appropriate for all involved in practical land management—farmers, graziers and local landcare groups.

QMDC is delighted to support this publication as it collates pasture science in a form useful to landholders. It will serve as a key technical reference to inform assessments and advice given to landholders and rural industry organisations

The Department of Primary Industries' efforts through Ian Partridge are to be commended in the presentation of this publication. Ian has been able to condense sometimes complex material and present it, with the support of good graphics and photographs, into a set of key principles on the need for pastures and on their selection, establishment and grazing management.

The production of this book is timely for all rural sectors in southern Queensland. The effects of likely climate change will need to be mitigated with good pasture information, and this publication provides a well-researched and well-communicated record of current information. QMDC has no hesitation in encouraging all rural industry stakeholders to read and consider.

Bob Walker

Formerly Regional Coordinator
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Queensland Murray Darling Committee

Acknowledgments

The editors acknowledge the authors of the relevant original papers presented at the 7th and 8th Australian Tropical Pasture Conferences.

7th Australian Tropical Pastures Conference, Tropical Grasslands, Volume 41, No. 3, (2007)

Andrew Biggs, *Department of Natural Resources and Water, Toowoomba, Queensland.*
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Mark Silburn, Brett Robinson and David Freebairn, *Department of Natural Resources and Water, Queensland.*
Why restore marginal cropland to permanent pasture? – land resource and environmental issues

Richard Silcock and Walter Scattini, *Department of Primary Industries and Fisheries, Queensland.*
The original native pasture ecosystems of the Eastern and Western Darling Downs

David Lloyd, Brian Johnson and Sue O'Brien, *Department of Primary Industries and Fisheries, Queensland.*
Which pasture species and should they be mixed?

Sid Cook, *Queensland Murray Darling Committee, Queensland.*
Principles of pasture establishment

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The realities of pasture establishment

Jeff Clewett and Nick Clarkson, *Agroclim Australia, Toowoomba, Queensland.*
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Mike Bell and David Lawrence, *Department of Primary Industries and Fisheries, Queensland.*
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David Lawrence, *Department of Primary Industries and Fisheries, Queensland.*
Pastures in farming systems - soil health and the benefits to crops

Andrew Richardson, *10 Mile Grazing Company, Goondiwindi.*
Leucaena: and cell grazing at 10 Mile Grazing Property

Peter Thompson, *Echo Hills, Wallumbilla, Queensland.*
Zero-tilling to renovate buffel grass

The names of the author's institutions are those relevant at the time of the publication of the original articles.

Photography

Most of the photographs have been taken by Ian Partridge, others by Col Paton, Jane Hamilton and Richard Silcock (DEEDI, QPI&F). We acknowledge Sid Cook (QMDC), Peter Thompson of Echo Hills, Andrew Richardson of Ten Mile Cattle Co. and Tony Illing of Illing Pastures for permission to use their images in this publication.

Contents

Best management practice for pastures

Before planting the pasture

In the two years before planting:

- Do not allow weeds in the fallow or preceding crop to set seed
- Cultivate to reduce reserves of seeds of grass weeds in old cultivation soil.

Planting the pasture

- Ensure adequate moisture in the soil (30–50 cm) before planting
- Sow only species suited to your soil and climate, and purpose
  - include legumes if suitable
- Buy good quality seed and ask for seed analysis
- Include enough seed of each species in the mix
- Make allowance in seed rate if seed is pelleted
- If possible, plant seed into the soil but never too deep (maximum 15 mm)
- Allow young plants to develop well-anchored roots before grazing
- Allow pasture to seed before grazing especially if establishment is patchy.

Managing the grazing

- Match overall stocking rate to carrying capacity
- Use feed budgeting to match stock numbers to available feed
- Always keep a ground cover of at least 40–50%
- Rest the pasture periodically for 6–8 weeks during the growing season
- Consider renovating run-down pastures.

Queensland Murray–Darling Basin

The Border Rivers and Maranoa-Balonne Catchments include some of the best agricultural lands in southern Queensland. But like so many farming districts, they suffer from some agricultural and environmental problems.

Our catchment problems

Some of the best cropping lands in the Borders Rivers have been farmed for nearly a century; this is in contrast to more marginal districts towards the south-west that have seen a major expansion of cropping only since the 1970s.

In the early years, crops yielded well as they fed off the inherent fertility of the soil. But decades of continuous cropping have reduced the levels of organic matter in the soil; this has been accompanied by a deterioration in their physical, chemical and biological properties—their soil health.

This decline in soil health has resulted in less efficient use of the rainfall, increased run-off and erosion, and a reduction in the quality of water in the streams and rivers. About 500,000 tonnes of soil are lost each year from the Maranoa–Balonne catchment.

Soil loss can be reduced by combining the traditional soil conservation practices of contour banks and waterways on sloping land, strip cropping on flood plains with the newer techniques of minimum or zero tillage and controlled traffic.

Some districts suffer from additional problems in that rainfall is even more marginal while, in some soils, salinity and sodicity at depth reduce root growth, water use efficiency and hence crop yields.

However, the restoration of soil organic matter (soil carbon) requires a period of several years under permanent grassland. Pastures are a means to maintain fertility in good soils and to restore fertility on run-down soils.

This book looks at the benefits of pastures—both permanent pastures and long-term phases in crop rotations—and at the management needed to establish productive and persistent pastures.

It makes much use of information presented at two recent Australian Tropical Pastures Conferences (*Pastures for Production and Protection* in 2007 and *Pastures for production, soil health and carbon sequestration* in 2009).

Good cropping land

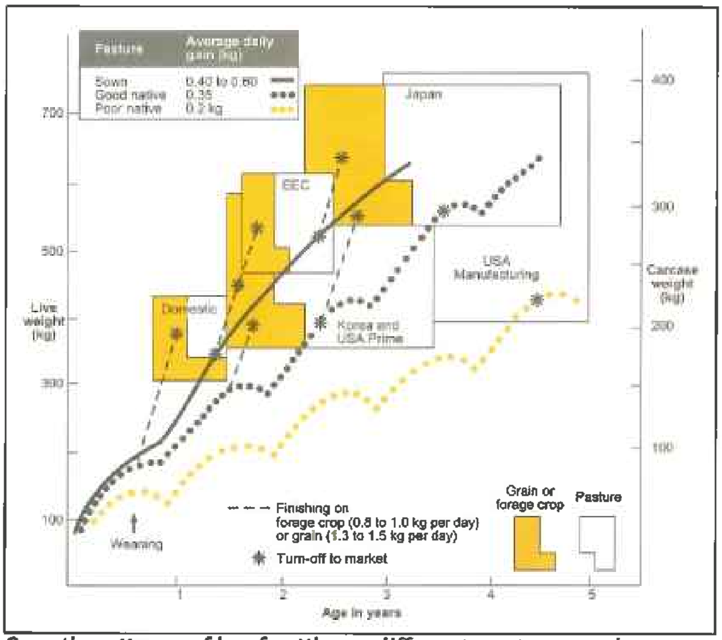
Marginal cropping country

Sloping country cropped with oats for decades and continuously overgrazed; now Condition C but could be improved with a sown permanent pasture.

More detailed information can be found in the papers in the Tropical Grasslands journal of the Tropical Grassland Society of Australia Volume 41, No. 3 September 2007, and Volume 43, No. 4 December 2009.

Reduced ground cover from heavy grazing over a run of dry years – Condition B.

Native pasture, over-cleared, over-grazed and highly erodible solodic soil – Condition D.



Growth patterns of beef cattle on different pastures and finishing options for various markets

Why plant pasture?

Planting a pasture may improve your productivity and profitability while protecting the environment.

Better productivity will come from more efficient use of rainfall by the permanent ground cover; this will allow stock to fatten faster, maybe at higher stocking rates. Better profitability will come from faster turn-off, more market options and reduced risk. Better protection of the environment, and the land as an asset, will come from better and more permanent ground cover than when under cropping.

Compared to marginal or abandoned cropping land or an existing overgrazed native pasture, a vigorous permanent pasture will:

- improve rainfall infiltration rates, reducing run-off and erosion that causes surface rills and gullies
- reduce soil loss from productive land
- reduce sedimentation of dams, water ways and flood plains
- improve water quality in creeks and rivers by reducing sediment loads and turbidity
- improve soil health by building up soil organic carbon and biodiversity.

The main land uses into which you might sow a pasture are:

- land in relatively poor condition and now under native pastures
- more fertile land cleared of brigalow
- cropping lands that are declining in fertility and productivity.

Why sow an improved pasture in an area of natural grassland?

Historically, those natural grasslands remaining after the initial clearing and cropping have not been ploughed up because the land has too many limitations. It may be too infertile, too rocky, too steep, or too prone to waterlogging to have been worth clearing in the past. The region may also receive too little and too variable rainfall for reliable cropping. Much of this native grassland is no longer in good condition today.

Planting an area of the property under sown pasture could:

- improve the land condition
- extend the pasture growing season
- increase carrying capacity
- provide a better quality diet for a special purpose
- increase your flexibility to target different markets
- allow you to spell areas of native pastures
- help restore degraded land.

Where can I sow a pasture on grazing land?

'Improved grasses' generally need higher fertility than do native grasses, and so tend to be planted on the better land types. We now have improved pasture species such as Bisset creeping bluegrass and Premier and Strickland digit grass that will grow well and persist on our less fertile soils.

Sowing any pasture grasses (exotic or indigenous) on overgrazed native pasture land is unlikely to be successful unless it will be managed better than the old pasture.

Naturalised buffel grass running out of vigour on light soils.

Is land under buffel grass now a natural grassland?

Pasture grasses have been sown on cleared and reasonably fertile brigalow lands for more than 50 years. Buffel grass, green panic and Rhodes grass were sown into the thick ash after brigalow scrub had been pulled and burned. These pastures were vigorous for many years but productivity has run down, and trees and shrubs have grown up again. Buffel grass has also spread onto the lighter soils in the Maranoa and become naturalised; thus buffel can be regarded as a 'natural grassland' from a productivity (but not conservation) point of view. Much of this naturalised buffel is weak and should respond in the short term to a renovation treatment.

Why would I sow a pasture on cropping land?

The best cropping lands (deep fertile cracking clays with good rainfall) will nearly always make more money growing a crop than under permanent pasture, but even the better soils can become degraded as their organic matter content declines.

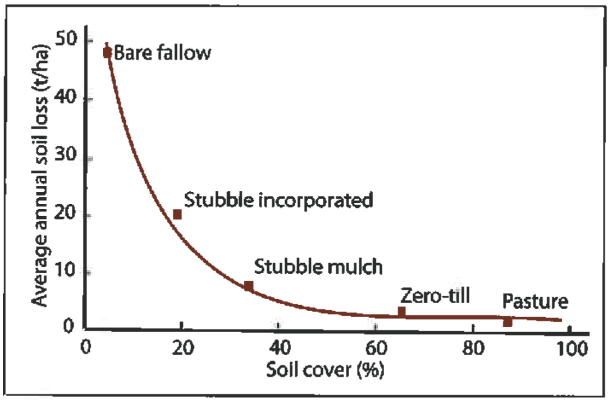
On some arable land, subsoil problems such as sodicity or salinity may become apparent after decades of continuous cropping.

The risks of cropping under a highly variable climate. (Above) Failed wheat crop from drought. (Below) Flooded cotton.

More marginal cropping lands may already be further down this track and no longer able to support reliable crop yields. These soils may be less deep or lighter with lower PAWC (Plant Available Waterholding Capacity) or have subsoil constraints that limit crop root growth, or be in a region where the normally low rainfall has become even less reliable in the past decade. Many good native pastures of Mitchell grass were ploughed up for cropping in the 1970s when cattle prices had collapsed and the rainfall was unusually good. Under the less reliable rainfall patterns of the 1990s and 2000s, cropping may give a good profit in only two or three years out of ten.

Or it may be a personal choice to move away from the tedium of driving tractors and headers for hours to a less demanding and less risky cattle rearing or fattening operation.

Ground cover from plants and surface trash improves infiltration of rainfall.



Soil loss is markedly reduced once ground cover exceeds 30%.

The mass of fine roots of grasses throughout the soil provide the organic matter (carbon) that improves soil structure. Compare this with the typical root structure of a forage legume on page 11.

What can a sown permanent pasture offer over cropping in terms of land management?

A well-managed sown pasture will provide good ground cover throughout the year and will improve soil structure and infiltration rates. This ground cover and the plant crowns intercept raindrops during storms and then allow the water to infiltrate faster.

This reduces run-off and the associated loss of the more fertile surface soil which holds most of the plant nutrients. Some nutrients, such as nitrogen, are soluble and may be leached deeper down the soil layers; others such as phosphorus tend to stick to the soil particles and end up in stream flow when the soil particles are carried away. Annual losses of nitrogen under cropping can be seven times higher than from permanent pasture; losses of phosphorus can be eleven times higher.

The soil needs to have good cover especially over the critical period between late spring and mid-summer.

In marginal rainfall areas, the more water that stays captured in the paddock, the higher the production.

How does a sown pasture improve soil health and condition?

Levels of soil organic matter (organic carbon) decline under continuous cropping.

Mean annual rainfall, runoff and suspended sediment losses from tilled and grazed buffel pasture catchments near Wallumbilla. (Jan 1990-Dec 1995) (From Freebairn et al.)

Catchment condition	Traditional tillage	Grazed buffel
Rainfall (mm/yr)	495	495
Mean cover (%) (range)	25% (5–50%)	70% (50–80%)
Runoff (mm/yr) (% of rain)	33 (6.6%)	9.6 (2.3%)
Number of runoff events	12	11
Suspended sediment loss (t/ha)	2.25	0.24

Grasses have a mass of fine roots which spread intimately between the soil particles. As these rootlets die off they are decomposed by soil fauna, eventually becoming humus and building up soil carbon. Cereal crops with more coarse root systems and plants with taproots do not leave roots in such intimate contact with the soil particles, and do not improve soil structure so well.

This organic matter improves soil structure, acts as a reservoir for plant nutrients, improves populations of beneficial soil animals and micro-organisms, and improves water infiltration.

How fast does rainfall infiltrate into the soil surface?

Rainfall does not infiltrate quickly—maybe only 3–4 mm per hour. Infiltration is faster on sandy soils but much slower if the surface is sealed with a crust. Soil organic matter levels affect the rate of infiltration; over 10 years of continuous cropping, the rate may decline from 3–4 mm per hour to less than 1 mm as the soil organic matter and soil structure declines.

On cracking clays, the rates of infiltration may drop sharply as the surface layer swells and seals when wet—but wide deep cracks are a major pathway for water to reach the deeper levels.

Cracks in swelling-cracking heavy clays are a major pathway for deeper infiltration.

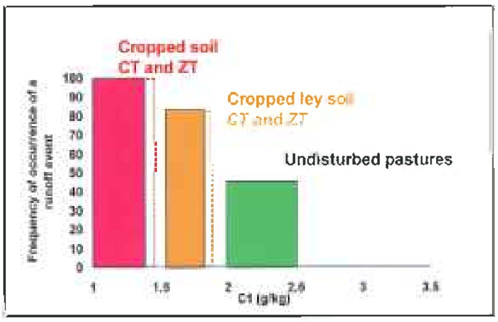
How many years before soil structure and infiltration declines under cropping?

The rate of decline does depend on soil type, and the cultivation practices. Infiltration in hard-setting soils will drop quickly (within 10 years, whereas others may take 20 years). Zero-till farming maintains higher levels of organic matter, better infiltration and less run-off than conventional tillage but is not as effective as a permanent pasture.

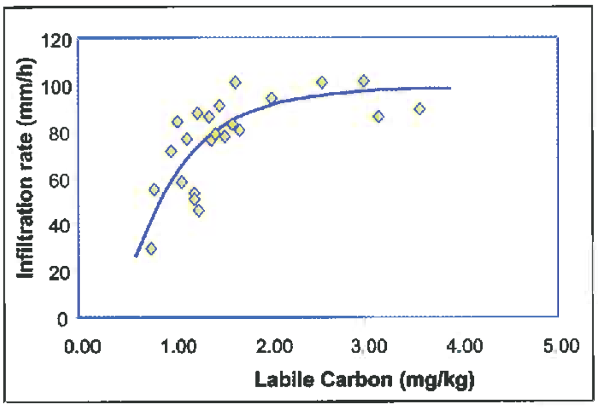
How many years before the pasture will improve infiltration rates?

Living grass plants and mulch from old or trampled leaves hold water over the soil for longer and reduce run-off. At the same time, the rate of infiltration is improved when holes from old grass roots and insects provide new paths for water.

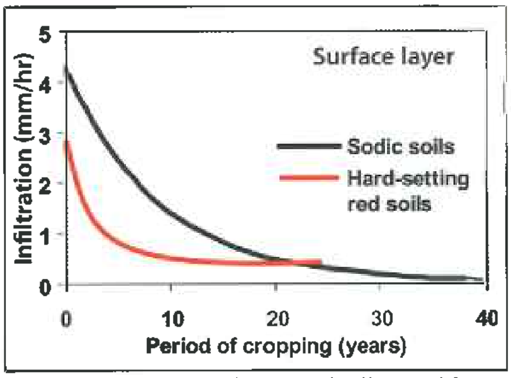
It is the organic matter (organic carbon) that improves the soil structure and improves infiltration.



As labile carbon increases, infiltration improves and runoff and erosion is reduced.



Infiltration improves as the organic matter (organic carbon) content of the soil increases.

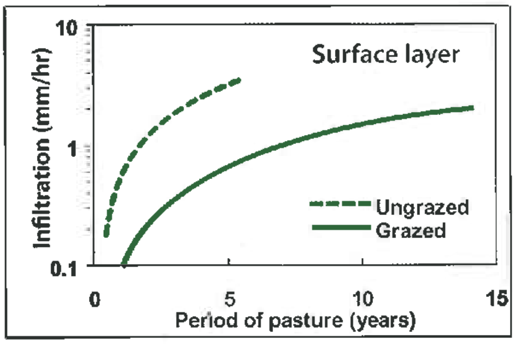


The rate at which infiltration declines with cropping depends on the soil type but can drop markedly after five years (after Connolly 1997).

Infiltration rates improve after 2–4 years of pasture but this naturally depends on the vigour of pasture—the species and plant density—and the intensity of grazing and trampling. It can take anything from 5 to 40 years of pasture for total soil carbon to return to the original pre-cultivation levels.

How can a sown pasture reduce dryland salinity?

Pastures may improve the infiltration of water into and through the soil but they also use more water (have higher rainfall use efficiency) than annual crops because they have a much longer growing season. Dryland salinity occurs when rainfall is not used by the vegetation in an intake area but moves down through the soil to raise the water table at the foot of a slope. The rising water table forces salt from deep in the soil profile to the surface. Dryland salinity can be lessened by planting deep-rooted trees or grasses in the intake areas to use the water.



Pastures may take 5 to 10 years to markedly improved infiltration (after Connolly 1997).

Soil carbon

Carbon in soils can be found as both organic and inorganic forms.

Inorganic carbon is found in the granules and pebbles of limestone (calcium carbonate) in alkaline soils with pH above 8. This mineral may appear as 'carbon' in a general total soil analysis but has little to do with soil health.

Organic or mineral carbon is derived from decomposing plant material, and is also present in a number of different forms. Roots and leaves are incorporated into the soil by insects and earthworms and are then broken down by soil biota. Incorporated plant material such as cereal straw or dead grass has such a high ratio of carbon to nitrogen (low nitrogen: high carbon) that the soil bacteria take up any available N to allow them to continue to reproduce. A crop planted now might well suffer from nitrogen deficiency.

Over a period of months or years (depending on soil moisture and temperature), these insects, worms, bacteria and fungi use the carbon in the plant material for energy to live and reproduce. As the ratio of carbon to nitrogen becomes reduced, the dead plant material becomes 'particulate organic matter' richer in the plant nutrients of N and P, but with some particles of the original plant material.

The decomposition continues over the decades or centuries with the particulate carbon becoming the amorphous, but even more nutrient-rich, humus. Add a few more centuries and the soil carbon may become resistant or inert–similar to charcoal. Inert charcoal may also be added directly to the soil when woody material is not burned completely.

The proportions of the different forms of carbon are important for soil health.

Crop residues on the soil surface (**weeks-months**)	
Buried crop residues and roots (**months - years**)	Extent of decomposition increases
Particulate organic matter (**years-decades**)	C/N/P ratio decreases (become nutrient rich)
Humus (**decades-centuries**)	
Resistant organic matter (**centuries –millennia**)	Dominated by charcoal –like material with variable properties

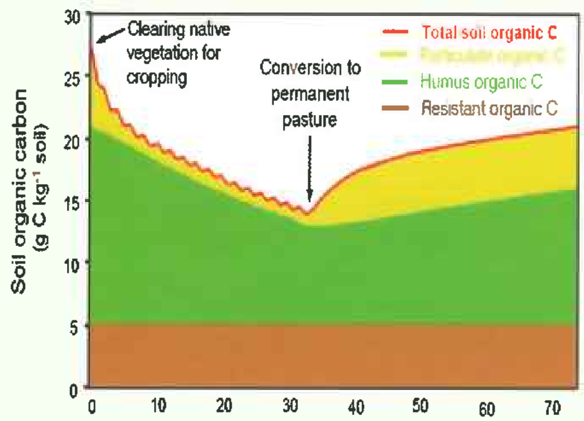
Some fifteen years after the natural vegetation has been cleared and the land cropped continuously, 30% of the total soil carbon may have disappeared, and along with it the nitrogen available to plants.

The remaining soil carbon has the proportions of about 10% particulate carbon, 60% humus and 30% inert charcoal.

The level of humus will continue to fall as it is exposed by cultivation and as the crops extract plant nutrients. After another 15 years of cropping, the total soil carbon may have dropped by almost 50%.

If then the land is put back to a permanent pasture, soil carbon levels will begin to recover and total soil carbon may return to levels seen after the first 15 years. However, the proportions of this total carbon may now be closer to 30% particulate and 40% humus (with the inert carbon remaining at 30%).

This lower proportion of humus means that the long-term store of soil nutrients has not

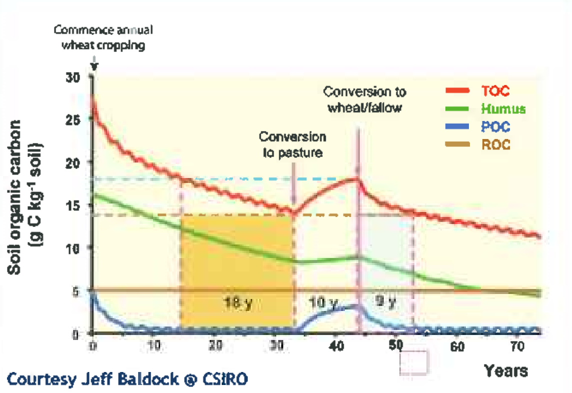


Courtesy: Jeff Baldock (CSIRO)

Changes in the different forms of carbon after land is cleared, cropped and returned to permanent pasture

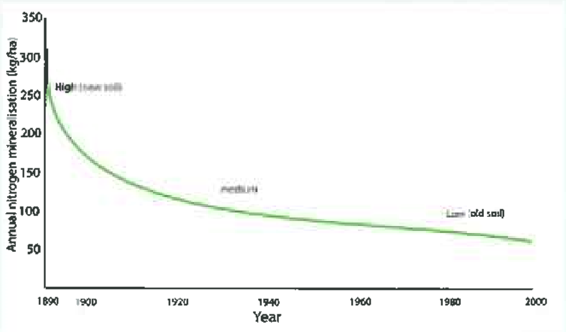
recovered. Permanent pasture will restore soil carbon of run-down cropping land but the levels may not return to the original state for many decades.

If the land is returned to cropping, the organic matter levels (now mainly particulate) will decline more rapidly than occurred in the early years of development.



Courtesy Jeff Baldock @ CSIRO

If the land is returned to cropping after a long-term pasture, the soil carbon declines quickly again because much of the carbon is only in the particulate form.

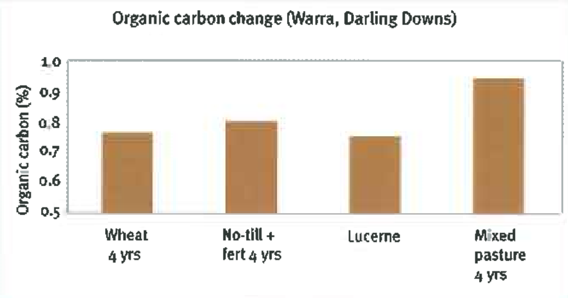


The rate of decline in the mineralisation of N after land was developed for cropping.

Plant nutrients in organic matter

Although organic matter increases in nutrient value with time as the carbon is expired by the soil fauna, the nutrients still had to come from somewhere. N could come from a legume or even from fertiliser in a fertilised pasture. Otherwise, it has to come from the soil.

Increasing soil organic C by 1% will require 900-1500 kg N/ha and 70-120 kg P/ha depending on the bulk density of the soil.



Pasture adds more organic carbon than lucerne or zero-till cropping.

The more vigorous the pasture, the more carbon in the soil.

The carbon quandary – keep it or use it?

Sequestering implies permanence. How permanent is any accumulated C?

Keep carbon as charcoal

- Charcoal carbon is in a form that will persist in the soil over the long term; it is sequestered.
- If carbon persists as charcoal, it will not supply nutrients, will not feed or activate soil biota, and does little for soil structure.
- But it will contribute to the soil Cation Exchange Capacity (CEC), may slow rates of acidification and could bind toxic aluminium; this may be useful on sands and on extremely acid soils such as areas where tropical rainforest is cleared for cropping.

Use carbon as particulate or humus plant material

- Carbon in this form will degrade quickly.
- As it degrades, it will feed and stimulate biota, build up soil structure and release plant available nutrients.
- The breakdown products of that plant material will contribute to CEC, slow acidification, and detoxify aluminium.
- This carbon is not sequestered (locked up permanently.).

Putting back the grasslands

Mitchell grass downs

Can we restore the vegetation to the original native grassland?

Although the idea of returning land to its original (pre-colonialisation) state may be desirable, it is not always practical.

It should be possible to restore a slightly degraded Land Condition B and may be possible to restore a moderately degraded (Land Condition C) grassland to the original vegetation by judicious management of reducing stocking rates, resting the land and maybe burning. This will depend on adequate populations of the desirable species to drop seed for new plants, low populations of weed grasses such as the wiregrasses (*Aristida*) and low populations of trees and shrubs, be they native or invaders. Degraded land (Condition D) cannot be restored without costing more than the economic value of the land.

Restoring cropping land to a grassland in the original ecosystem is not so simple and it may be more expensive and less productive than sowing exotic pasture species.

Poplar box with bluegrass understorey

What were the original pasture ecosystems in southern Queensland?

The original pasture ecosystems in the region ranged from almost treeless, dense mid-grass downs to woodlands and forests fringing brigalow–belah or cypress pine. This vegetation was determined by soil type and fertility, and by the frequency of fires lit by the aboriginal populace or by lightning.

The more fertile soils generally had denser grass growth, more frequent fires and thinner tree cover although the brigalow lands often had impenetrable forest or scrub without any significant grassy understorey to provide fuel for a fire.

The first colonists converted the best farming soils into cropping land, left the brigalow forests intact, put dense eucalypt and cypress forest into forest reserves, and grazed cattle and sheep on the rest.

Much of the better land was treeless downs country under natural grassland—under Queensland bluegrass in the eastern downs and under Mitchell grass in the downs of the drier west.

The main vegetation types that have been developed for farming include:

- Bluegrass and Mitchell grass grasslands
- brigalow–belah forests and scrubs
- Eucalypt forests and woodlands.

Brigalow forests generally had little or no grassy understorey.

How have the grasslands changed?

The eucalypt woodlands today probably have far less of the grazing-sensitive species such as kangaroo grass, common wheatgrass, plains bristlegrass, black speargrass and desert bluegrass, more of the less palatable pitted blue and unpalatable wiregrasses, and varying amounts of opportunistic Queensland bluegrass, Rhodes grass and buffel grass.

Before settlement, the eastern Downs probably comprised Queensland blue and king bluegrasses, kangaroo grass, satin top and plains bristle grass. These species can still be found in abundance on stock routes, but most of the eastern downs land has been ploughed and cultivated for about a century.

In the western Downs, the more resilient Mitchell grasses were still dominant until the 1970s, after which much Mitchell grass was ploughed out to plant wheat in that decade of good rainfall and poor livestock commodity prices.

Grasslands and woodlands now under cropping.

Can this country be restored to a pristine 19th century composition?

Can these marginal cropping lands or degraded native pastures be restored to their original vegetation? Major problems in restoration are how, with what, and how to keep that vegetation.

Should the native species present be allowed to colonise slowly or should seed of a mixture of native species be sown? Which species would be best for landscape stability in view of the soil degradation that has already occurred? And if this restored pasture is to be grazed, will it remain stable and will it be productive?

Old cultivation land is colonised quickly by roly-poly but only slowly by Mitchell grass.

Will the old native species colonise?

Queensland bluegrass is obviously well suited to the local conditions and heavier soils; it certainly does colonise well and this is often seen on abandoned cultivation land on the eastern downs. This bluegrass has an awned and fluffy seed that can be dispersed by wind; in addition, the seed has an almost unique ability to start to germinate but go back into dormancy if conditions turn dry, and then to re-activate with more rain.

But colonisation is a relatively slow process with low plant density in early years. Bluegrass does not compete strongly against weeds—most old cultivation land has a heavy weed burden of annual grasses and broadleaf weeds—while early open stands leave much soil bare.

Queensland bluegrass is a highly desirable, soft and palatable species; this makes it selectively grazed and unfortunately the plants can be easily pulled out as it has a fairly shallow root system. It is also short-lived so old plants need to be replaced regularly.

Mitchell grass can also colonise if any remaining Mitchell grass plants do seed but this is slow. Establishment is not helped by the drier westerly conditions but, once established, Mitchell grass can tolerate heavy grazing and drought, thanks to an extensive and deep root system.

Queensland bluegrass colonising a paddock of Bambatsi under careful grazing management.

Can we restore by sowing seed of the original native species?

Probably the answer is yes—if seed was available in commercial quantities and priced suitably for economic restoration. Several landholders are interested in trying native grasses such as Queensland bluegrass while engineering companies often demand native species for land reclamation.

Example of a brush harvester used for harvesting fluffy grass seed.

Queensland bluegrass has fluffy seeds that drop as they mature. Brush harvesters can be used to strip the mature seeds in sequential harvests and this technique is used commercially to harvest Bisset, Hatch and Floren bluegrasses. Problems encountered with Queensland bluegrass include the paucity of commercial seed production paddocks and low yields, hence a cost of $25–50 per kilogram.

Seed of curly Mitchell grass is easier to harvest and 'Yanda' curly Mitchell is commercially available at about $25–30/kg.

Seed of some native species is currently available in New South Wales from lines selected by the NSW Department of Agriculture. Therein lies a quandary for ecological purists—is seed selected and harvested hundreds of kilometres distant (Yanda is near Bourke) truly indigenous to the proposed area to be sown?

What about restoring the woodlands?

Allowing uncontrolled regrowth of eucalypts can result in much more dense stands of trees than the original woodland.

For lands that were originally poplar box woodlands, restoration implies the return of the trees. Should tree seedlings be planted if the land is clean after years of cultivation? Planting trees in a semi-arid region requires special treatment for seedlings and protection from fire and grazing during establishment. Or should they be encouraged by allowing regrowth which, although probably much more dense than in the original open woodland, can be thinned economically when it is small?

Is restoration economically feasible over large areas?

The cost of a restoration project would be high but this might be justified if there is a key ecological outcome—such as controlling an area of dryland salinity or providing habitat for an endangered animal or bird.

Revegetation using only native species is sometimes specified by government agencies for rehabilitation of mine sites or roadsides but at a cost of thousands of dollars per hectare and possibly poorer erosion control.

Tree planting would be expensive on large areas.

How can native grasses be established?

Establishing any grass is risky in an area of marginal and highly variable rainfall and the principles are described later. Fluffy seed can be difficult to handle through machinery although several seeders such as the Seabrook Seeder can handle fluffy grass seeds. Queensland bluegrass seed can be pelleted for ease of handling.

Queensland bluegrass seedlings have an almost unique characteristic of being able to re-grow after partial desiccation during a dry spell.

A major problem in establishing any grass comes from competition from weeds such as fleabane, liverseed grass, amaranths and mint weed in old cultivation land and from, for example, Mayne's Pest which can re-establish from roots chopped up while preparing a seedbed.

Sown pastures for marginal cropping lands

Sowing new pastures

Why plant an introduced grass?

Most introduced grasses were native species in their country of origin, be they panics from Africa or bluegrasses from Asia. Seed has been collected from hundreds of individual plants with good characteristics over vast areas. After quarantine, these accessions have been evaluated in Australia over a range of agro-ecological conditions, and those with the best agronomic features have been selected for release as cultivars.

This selection process looks at, for example, their vigour, form of growth, feed quality, palatability, tolerance of grazing, potential weediness, ease of establishment, seed yields and ease of harvest. Thus introduced species are likely to be cheaper to plant, more vigorous to provide ground cover and more productive over a longer growing season than most native species. But they may require higher soil fertility and sometimes better grazing management than the natives.

Buffel grass

Why plant legumes?

Legumes fix nitrogen from the atmosphere for free. This nitrogen is fixed by Rhizobium bacteria in the root nodules and increases the protein content in the plant.

Besides improving the quality of the livestock diet, nitrogen is also added to the soil through leaf drop, sloughing of old nodules and through the dung and urine of the grazing stock. Of course, nothing, including nitrogen fixation, is 'for free'. The Rhizobium bacteria use energy from photosynthesis by the legume plant so that the total production from a legume is less than that from a grass. The bacteria also have a higher demand for sulphur for making protein and for phosphorus, and maybe for molybdenum, and these may have to be added to the soil for effective growth and fixation by the legume.

Typical root structure and nodules of a forage legume. Compare this with the fine root system of a grass on page 4.

Which grass and which legume where?

All species have edaphic adaptations—they grow better on some soils and under some climates. Some grasses may prefer higher soil fertility (green panic), be more tolerant of flooding (Bambatsi) or salinity (Rhodes) or lower fertility (Bisset bluegrass).

Grasses tend to be more widely adapted whereas many legumes often have quite specific requirements.

Most tropical forage legumes have been selected for more free-draining light soils but the temperate medics and lucerne and Desmanthus, Caatinga stylo and leucaena are suitable for heavier soils.

Desmanthus is cool-tolerant and will grow on neutral to alkaline soils.

Pasture grasses and legumes for grain and pastoral systems

Grasses

Land and vegetation types		Kikuyu	Brunswick grass	Cocksfoot	Phalaris	Bahia grass	Tall Fescue	Angleton grass	Green panic	Rhodes grass	Silk sorghum
		Whittet Noonan	Blue Dawn	Kasbah Currie Porto	Australian Sirosa Sirolan	Competidor	Triumph Dovey Demeter	Floren	Petrie	Katambora Finecut	Silk Jaffa
		> 650 mm	> 650 mm	> 650 mm	> 650 mm	> 600 mm	> 600 mm	> 550 mm	> 550 mm	> 550 mm	> 550 mm
Eastern Uplands	Black earths	✓✓		✓	✓✓		✓	✓✓		✓✓	✓✓
	Soft Loams	✓		✓	✓✓	✓	✓✓	✓	✓	✓✓	✓
	Traprock			✓		✓					
	Friable sands	✓✓	✓✓	✓✓		✓					
Eastern black soil plains								✓✓		✓	✓✓
Brigalow belah	Friable clays							✓	✓✓	✓	✓✓
	Coarse clays							✓			✓✓
Mitchell grass/coolibah								✓		✓	✓✓
Poplar box woodlands	Clay loams								✓	✓	✓
	Hard loams									✓	✓
	Earths									✓	✓
Poplar box mulga											
Cypress/ bulloak	Friable sands									✓✓	
	Shallow loams									✓	
Flooded soils								✓			
Saline Soils										✓✓	✓

Legumes

Land and vegetation types		Arrowleaf clover	Balansa clover	Butterfly pea	Persian clover	Strawberry clover	Gland clover	Sub clover	Biserrula	Burgundy bean	Caatinga stylo
		Cephalu Zulu	Frontier Paradana	Milgarra	Nitro Plus Prolific	Palestine	Prima	Urana York Coolamon	Casbah Mauro	Cadarga Juanita Mixture	Unica Primar
		>650 mm	>650 mm	>650 mm	>650 mm	>650 mm	>600 mm	>600 mm	>550 mm	>550 mm	>550 mm
Eastern Uplands	Black earths				✓					✓✓	
	Soft Loams	✓	✓		✓	✓	✓	✓	✓	✓✓	
	Traprock							✓✓	✓		
	Friable sands	✓	✓			✓	✓	✓✓	✓✓		
Eastern black soil plains				✓						✓✓	
Brigalow belah	Friable clays									✓✓	✓✓
	Coarse clays									✓✓	
Mitchell grass/coolibah										✓✓	✓
Poplar box woodlands	Clay loams								✓	✓	✓✓
	Hard loams										
	Earths										✓
Poplar box mulga											✓
Cypress/ bulloak	Friable sands							✓	✓		
	Shallow loams										
Flooded soils			✓✓		✓✓	✓✓					
Saline Soils			✓			✓✓					
Soil pH		5-7.5	5-7.5	6.5-8.5	6-8	5-7	5-7.	5-7	5-7.5	6-8.5	6-8

in the Border Rivers and Maranoa–Balonne catchments

Creeping blue grass	Bambatsi panic	Digit grass	Forest blue grass	Gatton panic	Purple Pigeon	Tall finger grass	Indian blue grass	Sabi grass	Buffel	Sorghum/Millets	Oats
Bisset Hatch	Bambatsi	Premier	Swann	Gatton	Inverell	Strickland	Medway	Nixon	Biloela American Gayndah	Numerous	Numerous
> 450 mm	> 450 mm	> 450 mm	> 450 mm	> 450 mm	> 450 mm	> 450 mm	> 400 mm	> 400 mm	> 350 mm	Fallow	Fallow
✓	✓✓	✓		✓✓	✓✓	✓				✓✓	✓✓
✓✓	✓	✓✓		✓✓	✓	✓				✓✓	✓✓
		✓✓	✓✓			✓	✓				✓
		✓✓				✓✓					✓
✓	✓✓				✓✓					✓✓	✓✓
✓	✓✓	✓		✓✓	✓	✓			✓✓	✓✓	✓✓
✓	✓✓				✓✓					✓✓	✓✓
	✓✓				✓✓					✓✓	✓✓
✓✓	✓	✓✓	✓	✓	✓	✓	✓	✓	✓✓	✓✓	✓✓
✓		✓	✓			✓✓	✓✓	✓	✓✓	✓	✓
✓		✓✓				✓✓	✓	✓✓	✓✓	✓	✓
		✓				✓		✓	✓✓	✓	✓
		✓✓				✓✓			✓		
		✓				✓					
	✓✓										
	✓✓	✓				✓			✓		

Desmanthus	Lucerne	Yellow Serradella	Snail medic	Sphere medic	Barrel medic	Burr medic	Strand x disc medic	Woolly pod vetch	Round leaf cassia	Cowpea	Lablab
Marc Marc Plus	Pegasis UQL 1 etc	Santorini Charano Yelbini	Sava Silver Essex	Orion	Caliph Jester Paraggio	Scimitar Cavalier	Toreador	Namoi	Wynn	Caloona Ebony	Highworth Rongai Endurance
>550 mm	>550 mm	>550 mm	>550 mm	>550 mm	>450 mm	>450 mm	>450 mm	>450 mm	>450 mm	Fallow	Fallow
	✓✓		✓✓	✓✓	✓✓	✓✓	✓✓	✓✓		✓✓	✓✓
	✓✓		✓✓	✓✓	✓✓	✓✓	✓✓	✓✓		✓✓	✓✓
	✓			✓	✓	✓		✓		✓	✓
	✓	✓✓		✓				✓✓		✓	✓
✓✓	✓✓		✓✓		✓✓	✓✓	✓✓	✓		✓✓	✓✓
✓✓	✓✓		✓✓		✓✓	✓✓	✓✓	✓		✓	✓✓
✓	✓✓		✓✓		✓✓	✓✓	✓			✓	✓✓
✓✓	✓✓		✓✓		✓✓	✓✓	✓✓		✓	✓	✓✓
✓	✓✓		✓		✓✓	✓✓	✓✓	✓	✓✓	✓	✓✓
	✓				✓	✓	✓✓	✓	✓	✓	✓
	✓	✓			✓✓	✓	✓	✓	✓	✓	✓✓
		✓			✓	✓	✓		✓	✓	✓
		✓✓						✓	✓✓	✓	✓
	✓										
6.5-8.5	6-8.5	4.5-7	6.5-8.5	6-8	6.5-8.5	6.5-8.5	6.5-8.5	5-8.5	4.5-6.5	5-8.5	6-8.5

Seed heads of Premier digit grass and Strickland finger grass are similar (above).
Premier is tufted; Strickland is tufted but also has runners (below).

Short descriptions of some pasture species

(Check the tables on pages 12 and 13 for more specific adaptations.)

Tropical grasses

Rhodes grass is an excellent pioneer species, giving rapid ground cover but it is less drought tolerant than many of the other grasses listed for the region. Its early dominance from a high seed rate may smother species slower to establish.

Buffel grass is one of the most drought-tolerant species and is well suited for the drier westerly regions. Buffel is more of a coloniser than an invader; it does not invade good grassland but will colonise open spaces whether created by long-term overgrazing or by a grader along the roadside. Buffel also has a higher proportion of its total biomass in its root system than most grasses. This gives buffel its drought tolerance and persistence but also locks up much nitrogen in the undecomposed organic matter. This locked-up and unavailable nitrogen starves the buffel plant, which then declines in production. It may also prevent other nitrogen-loving and productive grasses from establishing, making buffel appear highly competitive.

Green panic is adapted to fertile, friable clay-loams but its productivity declines as soil fertility runs down. It is shade tolerant and very palatable. **Gatton panic** has wider adaptation to loam and clay-loam soils than green panic.

Bambatsi with a clump of Floren in foreground.

Bambatsi is first choice for heavy clays that can become waterlogged in summer but dry in winter. It can tolerate moderate soil salinity, has reliable establishment and good cool season growth.

Purple pigeon grass has a large seed which gives the best establishment on heavy clay soils because it can be planted deeper into moist soil. It is not very palatable when mature but cattle are happy to eat it when it is growing. Purple pigeon should be planted as a single species pasture to simplify grazing management.

Bisset creeping bluegrass is adapted to a wide range of duplex loams and friable clays of moderate fertility; it is thus an excellent choice for marginal and degraded cropping soils, and can tolerate heavy grazing. But seed is relatively expensive and establishment is often slow in the first year. Cool season production is poor.

Green panic pasture

Premier digit grass will grow well on soils from light, friable brigalow and Mitchell grass clay downs to the granite sands. It is palatable, cold tolerant and can survive dry conditions. **Strickland tall finger grass** is related to Premier and is adapted to similar areas as Premier. Premier is tufted while Strickland is tufted but also sends out runners.

Floren bluegrass is well adapted to heavy clay soils and is often used in frontage and flooded areas to compete with lippia. Seed of Floren is more expensive than that of the other grasses and it is less drought tolerant than Bambatsi.

Sabi grass is related to liverseed grass; it is palatable when green and a good coloniser of sparse grassland. However, the leaf drops after a frost leaving little bulk in winter.

Which species are most salt-tolerant?

Dryland salinity is not currently a major issue in the region but there may be local problems. Rhodes grass and Bambatsi are the grasses best adapted to soils of moderate salinity. Other species showing some tolerance are listed on pages 12 and 13. Any adapted grasses can be sown in the intake areas.

The Rhodes grass story

Rhodes grass is an excellent pioneer species. It is commonly included in pasture mixtures because it establishes quickly to give good ground cover and early grazing, and because seed is reasonably priced.

Its rapid growth from runners may allow it to dominate and smother other slower-growing grasses, and it may not persist well in districts with less than 550 mm of rainfall.

For drier districts, make sure that there are adequate amounts of other more persistent grasses, such as digit or finger grass, Bambatsi panic and Bisset bluegrass included in the mix.

Vigorous runners (stolons) allow Rhodes grass to give fast ground cover and early grazing.

(Left) A dense stand of Finecut Rhodes grass on black soil on the Darling Downs in January 2007.

(Right) The same stand 12 months later after receiving only 280 mm of rain during the 2007–08 drought.

Good years for naturalised medics come when a wet winter follows a dry summer.

Wynn cassia behaves as a free-seeding annual and is well eaten in the dry west.

Caatinga stylo has been selected for the heavier soils.

Temperate legumes

The medics. Medics are highly nutritious, providing good quality feed at a time when the summer-growing grasses are dormant and dry. Good medic years come in a wet winter after a dry summer during which the summer grasses have been heavily grazed and so offer no competition. Abundant fresh medic and a scarcity of grass can result in bloat in cattle.

The most widespread legume in the region is the naturalised burr medic. This self-regenerating winter-growing annual is found across neutral and alkaline soils but not on cypress pine–bulloak solodics or granite soils. Burr medic is not seen much in poplar box–sandalwood country where cutleaf and woolly burr are more common.

The most important barrel medics sown for permanent production are Caliph, Jester and Paraggio. They will set large quantities of hard seed in about 3 years in 10, no seed in 3 and only a little in the others. This hard seed acts as a soil reserve for a few years. However, in many western districts naturalised burr medic tends to overtake the sown varieties and become dominant with time.

Naturalised vetchs are found on the heavier soils whereas Namoi woolly pods vetch is more widely adapted.

Lucerne seed is often sown with tropical grasses in late plantings in March and April. Seed is cheap, the plant is deep rooted and drought-tolerant, and the leaf highly nutritious. But, under grazing, lucerne rarely lasts for more than 3 years.

Serradella is a winter species adapted to friable sandy soils west of the Condamine River and on the Granite Belt. Its winter growth complements the summer growth of the local grasses.

Tropical legumes

There are not many well-adapted perennial tropical legumes for southern Queensland as the winters are too cold for even subtropical species.

Desmanthus and **Caatinga stylo** are two species for the clay and clay loams; both are long-lived perennials that produce masses of hard seed.

Wynn cassia will grow on free-draining less-fertile soils; it sets masses of seed and acts as a self-regenerating annual in the drier and cooler regions. It is not very palatable under high rain conditions in coastal areas, but seems to be well accepted in the west.

Leucaena is a comparatively new option for deeper soils of moderate fertility in a region which was once considered too cold.

Leucaena

At one time, leucaena was not recommended for areas south of about Wandoan because of its lack of frost tolerance. The success of several plantings on commercial properties in the south is revising this old wisdom.

Leucaena's place in southern Queensland

Leucaena is a long-lived, drought-tolerant legume shrub with definite soil and climatic requirements. The leaf is very palatable with the highest quality feed (protein and digestibility) of any tropical legume—being equivalent to lucerne. However, it can become an environmental threat if not managed properly.

Leucaena–grass pastures can generate excellent weight gains in cattle year after year, but must have a vigorous grass between the leucaena rows for good animal production, ground cover and soil protection. Leucaena may also be the only tropical legume capable of fixing the quantities of nitrogen needed to prevent run-down in grass pastures.

Leucaena–grass pastures have been planted over large areas of clay soils in central inland Queensland because graziers see the economic and environmental benefits. It may well be less productive in southern Queensland but good production for 6–8 months over summer is still better overall than from any other legume.

Leucaena growth is slowed by low temperatures, and frost will kill all green leaf and even woody stems less than 30 mm diameter. Leucaena stands get frosted down to ground level but sprout again from the base in spring. Other constraints include the high cost of establishment, the difficulty of establishing a grass between the rows under low rainfall conditions, grazing management, mimosine toxicity, possible psyllid insect attack in hot and humid weather, and a potential to become an environmental weed in riparian areas.

This note is just a brief introduction to the possibility of using leucaena; anyone considering planting it should get hold of the MLA book *Leucaena: a guide to establishment and management* (see further reading on page 38). They must also read and follow the code of conduct developed by the Leucaena Network for planting leucaena (www.leucaena.net/codeofconduct.pdf). For example, do not plant leucaena in areas where rivers, creeks and flood channels can disperse seeds.

Leucaena in southern Queensland
– at Millmerran 14 months after planting

Note the bare ground and absence of competition needed to establish leucaena. Vigorous grasses must be planted later.

– at Glenmorgan 7 months after planting

(Above) Leucaena seedlings regrowing from their base after being frosted (Chinchilla).

Palatability

'Palatability' is relative. Cattle may not prefer to eat purple pigeon in a pasture with mixed species, but will certainly eat it when it is growing on its own.

On the other hand, some of the native wiregrasses have tough fibrous leaves and stems making them inedible or, at best, nutritionally poor. Some broad-leaf weeds are palatable and may be highly nutritious, providing the 'winter herbage'; others are totally unpalatable and may even be poisonous. No-one has been able to identify the causes of taste preference.

Silk sorghum gives reliable establishment but its fast growth and hunger for nitrogen can set back establishment of other pasture grasses in a mix.

Grazing stock on forage sorghum can allow a paddock of improved or natural pasture to be rested at critical times.

Sowing pastures

Should I plant one species or a mixture of species?

There are pros and cons for each—some on adaptation, some on the commercial reality of cost.

If you have a uniform soil type across the paddock, plant only the well-adapted species, especially if seed is reasonably priced.

If you have a gradation of soil types down a slope or mixed soils with gilgaied land, you could plant a mixture of species but each of these must be adapted to a set of conditions. The mixture will sort itself out across the landscape.

Sometimes a mixture will provide rapid establishment and ground cover from one species (for example cheaper Rhodes grass) while allowing a more persistent species with more expensive seed (such as Bisset creeping blue) to build up slowly as the pioneer species declines. But too high a sowing rate of a rapid growing pioneer may dominate and suppress some less vigorous species; some agronomists recommend that Rhodes grass should not exceed 20% of a mix while Bisset should be at least 10–15%.

But do not plant a mixture of species with very different palatabilities as cattle will eat the palatable species first so you will end up with a pure stand of the less palatable (for example, do not mix palatable green panic and the less palatable purple pigeon grass).

Shot-gun mixes without any reference to the paddock's soil types are not recommended.

Different species may have different growing seasons and this can extend the overall period for cattle weight gains; Premier digit grass and Katambora Rhodes, for example, start growth earlier in spring than Bisset.

Single species require less grazing management and also allow for opportunistic seed harvesting.

Should I add Silk sorghum to the mix?

Silk sorghum has a large seed and establishes reliably and quickly giving an early bulk of feed. It can be planted with grasses on more fertile soils but is best not planted on more marginal soils.

Silk is a hungry species and quickly takes up any available nitrogen; in soils of only moderate fertility, it competes strongly with the slower-growing grasses. Silk may give two years of good feed but at the expense of your costly permanent pasture.

Silk, or preferably more palatable forage sorghums, can be sown with other grasses in the rough seedbed left by blade ploughing. Cattle eat the high-sugar sorghums first allowing the grasses to establish.

Forage sorghums with high sugar content can provide good feed into winter and so allow pressure to be taken off a sown pasture at seeding time. Rapid growth of other forage sorghums in spring may allow the permanent pastures to be rested and recover.

How good are forage legumes?

Butterfly pea and burgundy bean offer longer-term production than lablab but rarely last more than three years. They are therefore best suited to shorter-term ley pastures in crop rotations rather than longer-term permanent pastures. Butterfly pea is more suited to the warmer regions further north while burgundy bean grows well in the southern districts.

All three can provide high-protein forage for a limited number of years; they fix substantial amounts of nitrogen in the soil and this is available for a following crop. However, the coarser root system of these legumes, as shown on page 11, does less to improve the organic matter and the physical attributes of the soil. For this and for good ground cover, a grass is needed.

The forage legume burgundy bean grows well on the cropping soils of southern Queensland ... but rarely persists in grazed pastures for more than a few years.

Establishing a sown pasture

Sown pastures have many benefits for production and profit, for soil health and for the whole catchment landscape.

The biggest problem in sowing a pasture is often establishment—because of the unreliable rainfall and competition for moisture and plant nutrients from grassy and broadleaf weeds in old cropping land.

The aim is to get enough plants established to reach maximum productivity as quickly as possible. This will give fast ground cover and a speedy return on the considerable cost of establishment. On old cropping land or degraded native pasture, you cannot just spread a low rate of seed and wait for the plants to build up over a period of years. Your new pasture may never be successful.

Burgundy bean (above) – in the first year (below) – in the second year.

When should I start planning for my new pasture?

You need to plan for establishing a pasture at least 12–18 months ahead. You might need a soil analysis if soil fertility is low, or to rip a hard-setting soil with a chisel plough to aid rainfall infiltration. Planning is especially important in preparing for pasturing old cultivation land that has a significant weed population. And make sure that you are not going to apply a residual herbicide to a crop that may damage young pasture seedlings in the next year. Legumes are particularly sensitive to a range of herbicides.

How can I reduce the risk of a failed establishment?

Think of planting a pasture in the same way as you would plant a crop. It's not so different—except that the grass seed is much smaller and the little emerging seedlings are less vigorous. The small seed is going to need contact with moist soil near the surface to germinate, and then the new rootlets will need more moist soil at depth to continue growth.

The best system is to fallow to accumulate soil moisture and control weeds, but to plant the pasture seed into dry soil in the months when good follow-up rain is most reliable. This is usually from mid-December and into January.

Competition from grass weeds is a major problem in old cultivation land.

(Above and below) Button grass

Urochloa or liverseed grass

Early planting (October) may also be successful in an unusually wet year, but November is best avoided because of the chance of heat-waves and strong dry winds.

Planting later will give a better guarantee of soil moisture and rainfall but the new grass plants must be allowed to reach a reasonable size before cold conditions slow growth and frost kills off the leaf. Rainfall reliability declines sharply after the end of February.

It might well be better not to try to plant a pasture in El Niño years in which winter and spring rainfall have been well below average and the outlook for summer rain is unfavourable.

How much moist soil is needed?

Pastures do not need as much moist soil as a crop, but a band of moist soil 30–50 cm deep and within 5–7 cm of the soil surface may be considered critical for grass seedlings to emerge and survive. This is obviously accumulated in the months before establishment from infiltrating rainfall with some sort of fallow. Earlier cultivation might be needed to remove existing poor herbage or to break any surface crust in hard-setting soils.

What is the best way to reduce competition from weeds?

Established but undesirable plants with existing root systems in an old degraded pasture will always get first call on moisture and nutrients, and so have to be removed by cultivation or herbicides.

Often the worst weed competition is seen on old cultivation land from weeds germinating at the same time as your planted seedlings. These reserves of weed seed in the soil can be extremely high, and stands of fast-growing grassy weeds such as liverseed grass (Urochloa), barnyard grass, button grass, mint weed, annual saltbush or amaranth can be so thick that they smother the slower-growing pasture grasses leading to a partial or completely failed establishment. Weed control is essential in previous crops up to 2–3 years ahead in order to minimise the weed seed bank.

What about cropping weeds before planting the pasture?

It may be possible to reduce the weed seed bank by growing and killing several crops of weeds. This involves at least three tillage cycles, waiting for rain and the weed to germinate and then ploughing again. Each ploughing brings a new load of weed seed to the surface which must be killed before it seeds.

Cultivation will increase water loss through evaporation but this is less serious than the competition for water once the pasture is planted.

One problem is that waiting for 3 crops of weed may push the pasture planting time back to March when rainfall is less reliable.

Chemical weed control with herbicides such as glyphosate and Sprayseed® help to conserve moisture but will not reduce the reserves of weed seed deeper in the profile during the current season; these will be brought to the surface with the final cultivation before seeding the pasture.

Establishing a pasture

Seedbeds

Aim for 30–50 cm depth of good moisture at planting, even though the surface 5–7 cm may be dry. Fallow to accumulate soil moisture with weeds controlled by either herbicides or cultivation. Small pasture seeds cannot be drilled deeply to reach moist soil. They can be planted on top of a dry soil; rainfall will wash the seeds into small cracks and allow germination.

Weed control

Do not plant pastures in paddocks that are known to have serious problem with annual weeds. Plan your pasture activities 2–3 years ahead and control the weeds in the fallows while cropping; seed banks of annual grass weeds can be reduced by 90% in 2–3 years if the grasses are not allowed to seed.

If weeds are less serious, reduce the weed seedbank by cultivating or spraying several times; then sow later in summer—but while there is still a good chance of follow-up rain.

Seed quality and seed rates

Sow only good quality seed; check the germination certificate and calculate the Pure Live Seed content. Sow rates appropriate for the species; compensate for coated seed—ratios of coating to seed average 5:1 (ranging from 2:1 to 10:1).

Species

Select species suited to the soil type, climate and conditions. Mixtures of grass species may allow for soil variation within a paddock and may reduce seed costs, but be aware of early domination by fast growing but less persistent species. Legumes supply nitrogen that makes the grasses grow more vigorously but, on their own, provide little benefit to the soil's physical condition.

Sowing

Preferably sow the seed into the soil but not more than 10–15 mm deep; press wheels will improve the contact between the seed and soil particles. Seed can be dropped on top of a freshly cultivated rough surface, but never on an uncultivated or sealed surface.

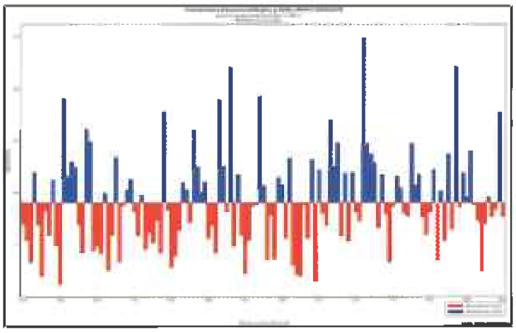
Sow the species when soil moisture and temperatures are right; do not sow winter-growing species such as medics during the summer months.

Management of establishing pastures

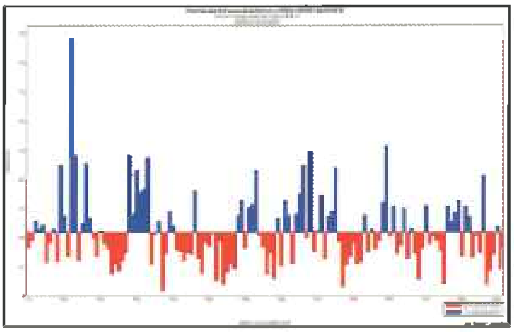
Do not graze until the grass plants have developed secondary roots and are seeding; a light grazing after 6–8 weeks may encourage tillering. If the initial plant population is low, allow the grasses to drop seed.

Seedling numbers. Aim for at least 6–8 mature grass plants per square metre.

Plant before good rainfall but, most importantly, with a good profile of soil moisture.



Rainfall is generally more reliable over the January to February period.
Roma rainfall:
(above) November–December (126 mm)
(below) January–February (157 mm).



What is a good seed rate?

It's a numbers game. You should aim for at least 6–8 mature grass plants per square metre one year after sowing and this generally means sowing 2–4 kg of seed per hectare (with the higher rates on the heavier soils). An old recommendation is to sow 1 kg of Pure Live Seed (PLS) per hectare. PLS encompasses the quality aspects below and equates to the recommended sowing rates given. Poor quality seed is a big issue for the industry.

Although our common grasses may contain 2–4 million seeds per kilogram, some of these are immature, dormant or sterile while fluffy seeds also contain florets and chaff. Field germination of good viable seed may be only 25–50%. Freshly harvested grass seed may be dormant for 6–9 months and should not be sown over this period. Seed storage is important as high temperatures or high humidity will reduce viability.

Always ask for the germination/purity certificate and buy good quality seed; cheap seed with a low germination is also likely to lack vigour as a seedling.

Seed rates for pelleted seed should be increased as it is commonly 5 (between 2 and 10) parts by weight of pellet material to 1 part by weight seed.

When should I plant?

The old advice was to plant your seed just before two weeks of rainfall, high humidity and good cloud cover! But rainfall in spring or early summer in inland southern Queensland is low and highly variable.

It is best to sow the pasture when the soil is warm enough and there is the greatest chance of getting follow-up rain within 5–10 days.

Rainfall is more reliable over the January–February period than in November–December—but still highly variable.

Over the Darling Downs and Maranoa, the average date of the first fall of 30 mm rain over 3 days is 1st November in La Niña years but over six weeks later (24th December) in El Niño years.

What is the best seedbed for my pasture?

Although the ideal seedbed will provide good contact between seed and small soil particles (peds), too fine a tilth on level country will often seal to a surface crust. Rainfall cannot infiltrate through this crust and small delicate grass seedlings may not be able to push through.

In old pasture land, existing plants of weedy-type grasses must be killed to prevent competition with the new seedlings. The old, but dead, grass plants on the surface provide protection against storm rains.

In lower rainfall districts, many like to leave a fairly rough surface of furrows and ridges; with rain, the seed and fine particles of soil fall into the furrow where the moisture concentrates and lasts for days longer in a micro-climate.

Seed should be planted at the time of the final cultivation to prevent any surface sealing from rainfall in between times: a freshly cultivated surface will have a mix of finer and larger soil peds between which the small grass seed will fall.

A better option for planting after a crop of wheat is to use zero-till into the existing stubble cover. Soil moisture is conserved, the stubble provides protection, weed seeds are not encouraged to germinate and airseeders can handle all types of pasture seed.

Some legume seedlings may be strong enough to break through a surface crust, but many grass seedlings cannot.

What is the best way to plant the seed?

Germinating grass seedlings are small and delicate and cannot push through any depth of soil; most grass seed should not be placed more than 10–20 mm deep—and this is usually too shallow to be in a moist layer.

The ideal is to place the seed into the fine surface and then press the soil particles around it. Some farmers use airseeders to drop seed into a shallow furrow before press wheels to compact the soil.

> More seed is lost by being planted too deep than from being broadcast on the surface.

Good pasture establishment, but starting to suffer from dry conditions.

Wide conventional planters cannot be guaranteed to plant small seed at a critical depth on uneven soil, but seed tubes can be pulled out of the planting boot to drop seed on the ground ahead of a press wheel.

Another practical system is to broadcast the seed onto the rough prepared soil surface. The seed will then fall or be washed by rain into a crack between the soil particles.

With a rough furrowed and ridged surface, seed falls into the furrow where it is more protected from drying wind. When it rains, water washes fine soil into the furrow and this micro-environment provides moist fine particles around the seed, maximising the chances of establishment.

Better establishment of grass seedlings in the furrows where rainfall concentrates.

Tens of thousands of hectares of pasture have been sown into the very rough soil behind blade ploughs. Establishment can be successful even though blade ploughing has to be done when the soil is dry and months before conditions are suitable for pasture seed to germinate.

Seed should not be broadcast onto a compacted or hard soil surface.

And if I'm planting a pasture after a crop...?

If you have zero-till equipment, use it to plant the pasture. Keep the stubble from a cereal crop as it helps conserve moisture and maintain a fallow through spring by using chemical weed control. Do not cultivate as this will bring more weed seed to the surface but you may need to run a set of phoenix harrows over the paddock before planting if there is a surface crust.

Coating or pelletting fluffy grass seed makes it much easier to put through the planter, but allow for the weight of the pellet material.

Seeders that can handle fluffy seeds.

(Above) An airseedeer mounted on a 4WD ute

(Below) Seabrook seeders.

Should the seed be rolled or harrowed in?

Compacting the soil particles around the seed would be ideal for good soil–seed contact, and may help on light soils—as long as it does not encourage the surface to seal.

On heavier clays, the dry soil peds may be too hard to press against the seed and if the soil is wet it may stick to the press wheels or rollers.

Harrowing with light harrows helps cover the seed, but on a rough surface it can bury seed too deep by levelling the ridges and furrows that give a suitable micro-climate. It can also drag any crop stubble or old pasture plants into heaps.

What about planting into heavy cracking clays?

Heavy cracking clays are a special problem when planting grasses; the surface tilth is often too coarse for good soil-seed contact. Pressing the soil around the seed improves contact. Purple pigeon grass was selected for the heavy clays because it has a larger seed than many other grasses and can be sown deeper (down to 50 mm) into moist soil.

What are the best types of planters for pasture seeds?

Most commercial planters can meter legume seeds because legume seeds are larger, harder and often smoother than grass seeds.

Seed of some grasses, for example green panic, purple pigeon and Bambatsi are smooth and flow well—sometimes too well because of their small size. But the fluffy seeds of grasses such as Rhodes grasses, buffel and the bluegrasses with awns or bristles do not flow well in seeders with, for example, fluted roller metering devices.

Fluffy seeds can be de-awned and pelleted for better handling. Pasture seeds can be mixed with fertiliser (for example 20-25 kg/ha of MAP) and sown through the fertiliser box. Grass seed should not be left in contact with superphosphate because the acidity can spoil germination. Fertiliser spinners throw light grass seed less than half the distance of fertiliser pellets.

A number of commercial seeders have been designed for grass seeds and these include the rolling drum seeders often seen behind blade ploughs and the Seabrook seeder. Some seed boxes have used peg tooth metering devices while air seeders handle most types of seed if they have suitable seed metering devices.

How can I control weeds while the pasture is establishing?

There is no way of chemically controlling grass weeds in an establishing grass pasture, but broadleaf weeds in a grass-only pasture can be sprayed with a selective herbicide (unless there is a legume there) after the seedlings reach the 4-leaf stage .

Dense weeds can be slashed. As weeds usually grow faster and may be taller than the grass seedlings, slashing will check them more than your grasses.

Slashing is non-selective, but not so grazing. Although cattle may eat some weed grass, they may select the more palatable young sown grasses and often uproot the plants.

Liverseed grass and barnyard grass are both annuals and will not compete seriously with your established grass after the first season as long as there is a good density of sown species.

You have enough of your own weeds without bringing in parthenium.

When can I start grazing a new pasture?

The earlier a new pasture can be grazed the earlier it will start paying its way, but this must not be at the expense of the pasture's longevity. Grasses can be grazed lightly once they have developed sufficient root system that they will not be pulled out of the ground, and a quick light grazing may encourage tillering.

Much depends on how many plants have established per square metre. If the stand is thin because of poor seed, poor establishment or poor weather, the plants may have to be allowed to drop seed to build up seed reserves for the next summer.

That's why it is important to do everything possible for good establishment.

What about toxicities?

Purple pigeon grass and buffel grass (and many other grasses) have high levels of oxalates. Horses whose sole diet is of these grasses can suffer from calcium deficiency resulting in'big-head' disease.

Bambatsi can cause photosensitisation and liver damage in sheep, and to a lesser extent in cattle.

Many sorghums, both forage or ratooning grain crops, can contain toxic levels of cyanide (prussic acid) in young drought-stressed leaf.

The temperate legumes, clovers, medics and lucerne, can cause bloat when eaten without some grass roughage.

Leucaena leaf contains mimosine. Cattle gorging on a flush of leucaena leaf after a drought when there is no grass available can suffer from acute mimosine poisoning leading to rapid death. Normally mimosine is broken down in the rumen to DHP which can cause chronic or sub-clinical toxicity over time. DHP toxicity occurs when cattle can eat plenty of leucaena over a extended period; it is handled by drenching the stock with a DHP-degrading rumen bug available through Queensland Primary Industries and Fisheries.

Pimelea toxicity is a serious concern on the lighter soils in the south-west. It is more common in native pastures but can be found in old run-down buffel.

Pimelea is a serious concern on lighter soils in the south-west and can be found in rundown buffel pastures.

Less risk from climate variability with pastures

Our variable climate creates a major risk for all agricultural operations, but animal production from pastures is less risky than grain production from cropping.

To yield well, crops must grow strongly throughout their life, but they can be affected at critical stages of development by dry conditions, frost or heatwaves. Then when the crop is ready for harvest, excessive rain may spoil the grain. Pastures, on the other hand, continue growing throughout the season, rarely have a highly critical stage of development, and can accumulate growth from rainfall in one month to be available later.

However, there is a highly critical risk stage in a pasture and that is during establishment. Grass seed is small and the germinating seedling is fragile; subsoil moisture and follow-up rains are needed to keep the seedling going. You would not plant a crop into a dry soil without good prospects of rainfall, so don't try it with a pasture.

El Niños and La Niñas

Much of the seasonal rainfall variability in southern Queensland is associated with ENSO (Southern Oscillation–El Niño); nowadays, nearly everyone is aware that El Niño is associated with low rainfall, and many check the value of the SOI (Southern Oscillation Index) as a general guide to the chance for good rainfall.

But ENSO also influences cloud cover and this affects solar radiation, day and night temperatures, evaporation and humidity—all the factors that influence plant growth—so the overall effect of ENSO on plant growth may be larger than the direct effect on rainfall.

Seasonal forecasting

The value of seasonal forecasting in inland southern Queensland is strongest for rainfall and plant growth during spring and summer. Over the last hundred years, whenever the average SOI in winter or spring has been negative (below –5), pasture growth in summer has been 20% below the long-term average. In contrast, when the SOI has been positive, pasture growth has been 25% above the long-term average. But SOI-based forecasts are not much use for autumn rainfall and there is little growth of tropical species in winter.

Seasonal forecasts are given as probabilities. If they show that there is a 40–60% chance of getting better that average rainfall, that's too close to average to change management, but if there is only a 20% chance of getting above-average rainfall for the coming season, it is worth paying attention. The SOI is not a perfect indicator but ignoring it increases the chance of making a bad decision.

Soil moisture profiles may still be one of the best indicators of success when planting a pasture.

Seasonal forecasts based on variations in your local long-term rainfall data (as in the Rainman program) are the most relevant and useful.

Is seasonal climate forecasting useful to me?

Possible opportunities for using seasonal climate forecasting include:

- choosing the season or year in which to establish pastures
- adjusting the timing of planting
- adjusting stock numbers and grazing pressure by feed budgeting
- possibility for and desirability of burning.

Watching the MJO

The MJO (Madden-Julian Oscillation) is a wave of low pressure that passes over northern Australia about every six weeks. If there is moisture in the atmosphere, the MJO may trigger rainfall and indicate a good time for planting. If it passes without triggering rain, there is a good chance that it will remain dry for another week or more, so it may be best to defer planting.

Pasture management

Your aim should be to produce a livestock product suited to the most profitable market while maintaining the land and pasture in a sustainable manner. This means having productive pastures—and maybe integrating with summer or winter forage crops to maintain growth rates.

> *"Look after your pasture and your cattle will look after you."*

Recent years of below-average rainfall aided the degradation of many sown and native pastures. Pasture condition often deteriorated badly—as seen in the decline of many desirable species. For example, much of the Rhodes grass planted in pasture mixtures died out during the extended drought—even in more easterly higher rainfall areas—and did not recover. Many pastures are now dominated by poorer annual grasses and weeds

Not all degradation is due to the weather. Much is man-made because of the failure to reduce animal numbers at critical times. Often you can see vigorous pasture in the road reserve while the paddock over the fence is bare or full of roly-poly.

What are the main principles for managing pastures?

The aims of pasture management are to encourage and keep the desirable species productive.

This will provide a feed reserve if it turns dry, and will ensure good ground cover that:

- protects the soil surface
- encourages good water infiltration
- improves efficient use of all the rain that falls
- allows rapid response when it does next rain
- competes with the less desirable species, including broadleaf weeds
- reduces run-off and soil erosion
- and improves profitability.

Which are the desirable species?

Plants in any pasture can be classed as desirable, not so desirable or completely undesirable.

The desirable grasses are:

- perennial
- persistent
- palatable
- productive.

A pasture in good condition contains a high proportion of desirable species.

A well-managed pasture of Finecut Rhodes and Bisset creeping bluegrass

Fencing off an area in a paddock can show how much grass does grow, and the effects of grazing and spelling.

Some droughts are man-made by inappropriate stocking rates.

Appropriate stocking rates result in fatter cattle and less risk.

CSIRO

Under constant heavy grazing, the root system, as well as the top growth, of a grass becomes much smaller, and it cannot respond well to rainfall.

How do I keep these desirable species productive?

The most important impact you can have is through adjusting stock numbers, the second is through your grazing management.

The number of stock that you carry must be matched to the feed available and, in many cases, this may mean reducing stock numbers.

Adopt a feed budgeting approach to grazing management.

Surely more animals mean more money?

Too many animals can mean spending more money rather than making more.

While high stock numbers theoretically increase the total liveweight gains per hectare (up to a point), the individual animals often fail to meet the target market weight and may have to be kept over for another year. This may entail feeding with hay or supplements over winter.

Many farmers and graziers know that they are stocking more heavily than they should but blame economics for pushing their system too hard.

What are the benefits of lower stocking rates?

The immediate benefit is through the pasture being in better condition (as listed previously) and through the better diet that the stock can select.

Animals grow faster, giving more market options, better turn-over, less weak animals, less need to hand-feed during winter, less need to provide hay or grain or cotton seed during a drought, more cash available from selling off the extra stock and generally less risk, less worry and less labour.

Selling off excess stock before they lose condition will mean better prices and more money in the pocket—or helping to reduce the overdraft.

What happens to a grass plant that is continuously grazed heavily?

Most grasses tend to have approximately equal amounts of mass above and below the soil surface. Thus a plant that has been reduced to only a small crown with a few tillers will have a much smaller root system than a large plant. This smaller root system means that the plant can access less water and nutrients from the soil and will not grow to its full potential, provide full ground cover or respond well to rainfall, and is more susceptible to drought.

Other effects of heavy grazing might be beneficial with a higher proportion of fresh green leaf to old or dead leaf and less flowering and seed set, but this may not be sustainable.

Heavy defoliation during the winter when the grass is dormant has little effect on the plant itself but will reduce the ground cover present when storm rains hit in early summer.

What happens to a pasture that is continuously grazed heavily?

The pasture opens up exposing more bare soil. The figure on page 4 shows how poor ground cover greatly increases erosion and soil loss. This loss is from the top most fertile part of the soil and ends up making streams and rivers full of sediment lowering water quality.

Once a native pasture has been seriously degraded by overgrazing (Land Condition D), it is not usually economic to replant with either native or improved pasture, so good grazing management is paramount.

If an improved pasture is overgrazed, for example during a drought, it is usually possible, even if costly, to replant.

***Heavily-grazed** open pastures increase the loss of topsoil.*

How important is ground cover?

Good ground cover by living plants or mulch prevents dispersal of soil particles by raindrops, holds rain water on the surface soil for longer, keeps cracks open on the soil surface and through the profile allowing better infiltration and reduces evaporation from the surface soil layers. Living plants can then make efficient use of the rain that does fall.

Rainfall use efficiency from a pasture with good ground cover may exceed 50% compared to only 15% from bare surfaces.

When bare soil reaches 70% (30% ground cover), the amount of soil lost in sediment increases dramatically (see figure on page 4).

What is the difference between carrying capacity and stocking rate?

Carrying capacity looks at the long-term overall productivity and average stocking rate of a land type in its current condition. If the land condition improves over time with better grazing management, the carrying capacity may increase gradually.

The stocking rate may fluctuate above or below the carrying capacity on a yearly basis depending on the season. But if the stocking rate continuously exceeds the carrying capacity, the condition of the pasture will decline (and the carrying capacity will fall).

Andrew Richardson

Good pasture filters the sediment in slow-moving floodwater.

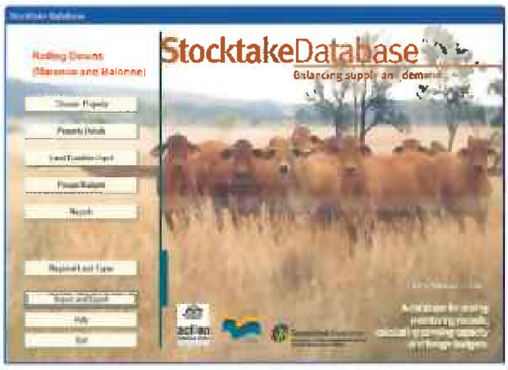
What is 'pasture utilisation'?

Pasture utilisation refers to the proportion of annual pasture growth that is eaten by stock. The term is now used only in calculating carrying capacity when it is applied to the long-term average potential annual growth of pasture.

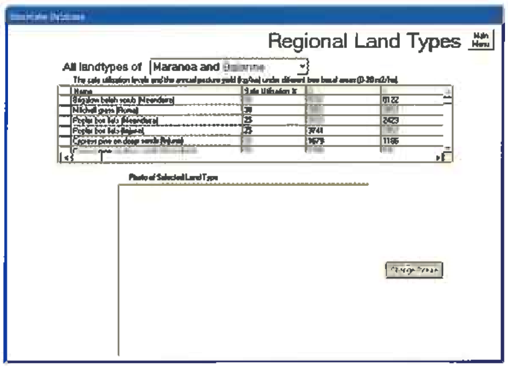
Higher utilisation reflects heavier grazing.

For the more fragile native pastures, no more than 20–30% of the total pasture growth should be eaten under a sustainable carrying capacity.

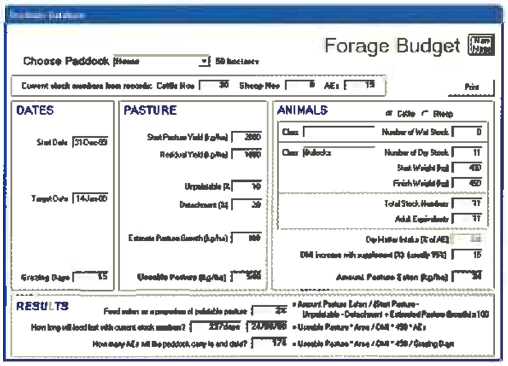
For improved pastures with grasses that have been selected for greater tolerance of grazing, the utilisation level can be higher at 30–40%.



Stocktake is a computer program for storing monitoring records, and a database for calculating carrying capacity and forage budgets.



Example screen of pasture production and utilisation levels for different land types.



Example screen of Forage Budget calculator

Remember: Carting and feeding bulky material like hay is much more expensive than feeding protein (or non-protein nitrogen) to stock that can eat dry roughage left in the paddock.

How can carrying capacity be calculated?

Carrying capacity for many native and improved pastures has been calculated from the potential annual pasture growth, the forage demand by livestock and an appropriate safe level of utilisation.

This has been done using the GRASP Pasture Growth model that simulates pasture growth based on local soil type, long-term climate patterns, tree and shrub densities and land condition. These carrying capacities have been validated against a number of long-term grazing trials and general grazier experience. Carrying capacities for a wide range of pasture land types are available in the QPIF software "Stocktake", or can be customised for your property when you attend a GLM (Grazing Land Management) workshop.

How can stocking rates be calculated?

Long-term stocking rate

Long-term stocking rates should equal the carrying capacity of the land and pasture as calculated using the pasture growth model just described. Experienced graziers in the region will have a feel for what their carrying capacity should be, but it pays to be objective and seek as much information as possible.

The actual stocking rate in any year may have to be adjusted during the summer if the rainfall is markedly different from the long-term average. This involves feed budgeting based on the amount of forage in the paddock and ensuring that enough pasture remains for grazing over winter and spring and to provide ground cover during the first storm rains.

Shorter-term stocking rates – feed budgeting

Shorter-term stocking rates (for a few months or a season) can be calculated based on the amount of feed in the paddock. The amount of herbage present can be estimated by comparing against photo-standards or by cutting some quadrats, weighing the grass, drying a sample and weighing the dry weight.

Dry season stocking rates. The amount of forage available for grazing stock can be calculated from the standing dry matter at the end of summeer, less losses through leaf fall and trampling, less unpalatable species that will not be eaten, less at least 1000 kg of dry material in the paddock to provide ground cover during the first storm rains. The net feed available is divided by daily consumption of the low-quality forage per animal class to calculate how many stock can be carried until the start of the next growing season.

Making further estimates as the dry season progresses allows you to forecast early whether there will be sufficient feed until the pasture starts growing again. Stock numbers can be adjusted well before feed runs out, thus avoiding forced sales when prices are low.

Feed budgeting on improved pastures. Management of improved fattening paddocks again involves monitoring the pasture to estimate how much grass is available and how many stock it can fatten.

The principles for fattening are to allow the animals to eat as much as they want (daily intake of dry matter of 2-2.5% of their body weight) but always to leave enough green leaf (covering at least 50% of the ground) to intercept solar radiation, and to leave enough material in April to carry the required stock over winter.

It always pays to err on the conservative side; this means more forage available in case of unforeseen problems such as dry spells or opportunities to buy if cattle prices are low.

What about those roos?

Your property may be carrying a considerable number of kangaroos and wallabies, and you may need to make an allowance for their consumption of pasture. They often congregate in paddocks that are being rested and can slow or negate recovery of pasture condition.

Feeding too many roos can upset your grazing management plans.

What are the different effects of types of livestock?

Cattle and sheep (and goats) are ruminants which have incisor teeth only on the lower jaw but pull off the leaves of a grass plant with their tongues (cattle) or lips (sheep).

Cattle like tall herbage and are often used to reduce the height of a tall pasture before sheep are put in to graze closer to the ground.

Horses have incisor teeth on both jaws; they are fussy eaters preferring grass to weeds but, when they eat weeds, the seeds pass unharmed in the dung. Hand-fed horses at high stocking rates in small paddocks can quickly ruin a good pasture; they need plenty of area to graze over so that areas of pasture can be rested.

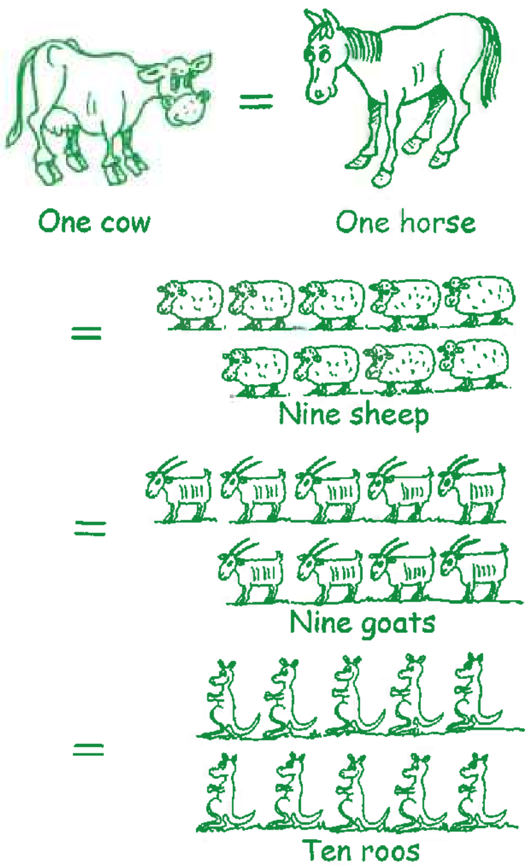
Goats like to eat some browse, and so may help to control some weeds. While sheep frequently follow cattle, cattle do not like following goats—maybe because they don't like the strong smell left on the pasture.

Best Management Practice for grazing

- Match overall stocking rate to carrying capacity.
- Adjust stock numbers to grass growth conditions each year to maintain ground cover above 40–50%.
- Periodically spell pastures for 6–8 weeks when there are good growing conditions in the less reliable rainfall patterns of southern regions; spelling could be early to allow the tussock bases fill out or late for plants to set seed.
- Even out grazing at the landscape level, the patch level and the plant level. Use techniques like fire, fencing to land types and subdivision, even spacing of water points, distribution of supplements.

Other points to consider in a grazing system would be labour requirements, cost of new infrastructure and the grazier's management skills or life style.

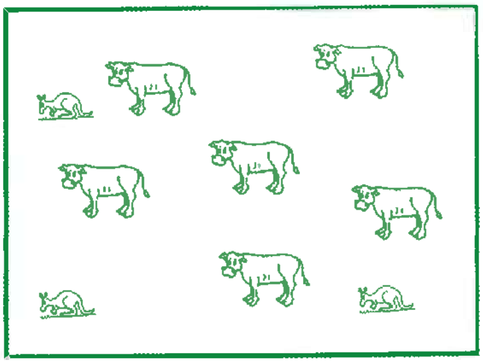
Approximate Stocking Equivalents



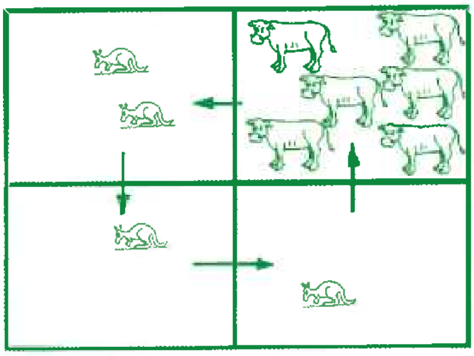
Diet preferences of grazing animals

	% of diet		
	Grass	Forbs	Browse
Horses	90	4	6
Cattle	70	20	10
Sheep	60	30	10
Goats	30	40	30
Kangaroos	60	30	10

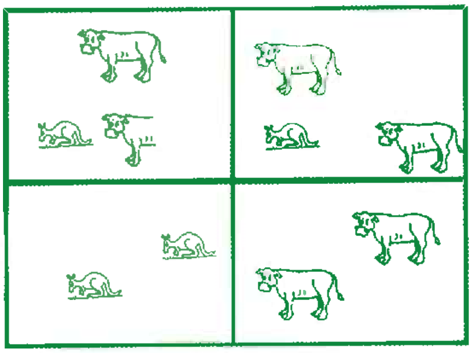
Grazing systems apply to all livestock —sheep as well as cattle.



Set stocking



Rotational grazing



Set stocking with spelling

Grazing systems

How you move your stock around can affect your pasture and ultimately land condition. Some graziers with large paddocks may set stock, carrying the same number of animals on an area each year; farmers with several smaller paddocks of improved pastures and maybe forages are more likely to move their animals around.

The main systems are set stocking, rotational grazing and cell grazing—with many variations of each.

Whichever system is used, regular spelling will help to maintain or improve pasture condition. Spelling means a period of 6–8 weeks without grazing when there is sufficient moisture for continuous growth: it allows perennial plants to regenerate. Early season spelling allows plants to bulk up; late season spelling allows them to flower and drop seed.

Set stocking

In set stocking, the same number of stock are carried each year and kept in the paddock all year. This system is frequently used for breeders and bullocks on more extensive properties. As long as the stocking rate is aligned with the carrying capacity, this can be a good system in that it allows animals to select a nutritious diet and to grow well. However, set stocking can create problems in and after dry years as it may take at least two years for a pasture to recover from a drought year. Other problems can arise from patch or uneven grazing in large paddocks and the loss of the most palatable species as cattle preferentially select them.

One way around yearly variability in grass growth is by 'trading' or putting and taking animals from the base number.

Periodically spelling paddocks over summer will keep the desirable species strong.

Rotational grazing and spelling

There are many systems of rotational grazing depending on the number of paddocks and the frequency of moving the stock. Stock handled more frequently are quieter and each paddock is rested allowing the more heavily grazed species to recover.

Paddocks should periodically be rested (spelled) for an extended period of 2 months in spring or autumn to be allowed to recover or to set seed; but this should not result in heavier-than-usual grazing on the other paddocks.

Some producers grow an area of forage sorghum or forage legume to allow the pastures to be rested.

The principle is to work out how many animals can be comfortably carried over the whole pastured area (stocking rate) and then divide that pastured area into a number of paddocks. All the animals are rotated around, each paddock being grazed for a length of time that will depend on the pasture growth that season. The regular spelling and feed budgeting throughout the year help maintain the desirable species.

Short duration forage budgets can help to forecast feed shortages before they become serious.

Once again, the overall stocking rate is more important than the grazing system.

Cell grazing

Cell grazing, or short duration grazing, is an extreme form of rotational grazing with the paddock divided into a large number (for example 50) of cells (or cells divided into paddocks). Cattle graze a cell for only a couple of days or even less. They graze everything down to a certain height before being moved on.

The cattle are quiet as they become accustomed to being moved. Because there is less opportunity for preferential grazing and the pastures are regularly spelled, the best species are allowed to remain vigorous and may even improve with time.

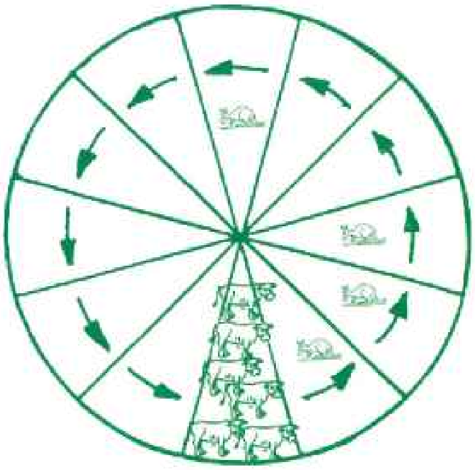
Some of the benefits from cell grazing may actually arise from the more intense interest that the farmer takes in the pastures themselves—as well as in the cattle. The manager regularly monitors the pasture in each cell and is thus forewarned of an impending feed deficiency or opportunity.

Forage planning is done regularly and requirements for 12 months ahead are constantly revised, both for pasture condition and animal health. It is claimed that increased calving rates result from this, as well as better timing for selling or buying.

Smaller sub-divisions may result in more even grazing over the whole property leading to increased stocking rates.

However, the animals do not get a chance to select a diet better than the bulk pasture when they are forced to eat all species. Thus cell grazing may be a better system for backgrounding than for fattening or finishing cattle. And there's the human aspect—many farmers or graziers do not wish to become 'dairy farmers' for 365 days of the year!

Again, the overall stocking rate is critical. It should not be increased in the early years of cell grazing but may be later if the pastures do improve with time.



Cell grazing—many animals for a short duration and then a long period of rest.

Cell grazing is good for the pasture but may not allow maximum growth rates of the animals.

This system may thus be better for backgrounding for the feedlot (left) than for finishing cattle off pasture.

Dense brigalow regrowth greatly reduces pasture growth and makes mustering difficult.

The blade plough is used to control brigalow regrowth and to renovate a run-down pasture or to establish new pasture species through rolling-drum seeders. It is effective but expensive.

Unpalatable African love grass has been spread by mowers along parts of the Warrego Highway in the Maranoa. Don't bring it into your paddocks on vehicles or machinery.

Weeds

Weeds in pasture are plants not wanted in that paddock; they may be woody species (both native and introduced), broadleaf herbs or unpalatable grasses (both native and introduced).

Check that seed of unwanted weeds are not introduced in pasture seed or machinery.

In all cases, the best protection from weeds is a vigorous pasture as many weeds increase or invade as the pastures open up under continuous overgrazing.

Woody plants

Woody 'weeds' in southern Queensland include woody regrowth of eucalypts, brigalow suckers and sandalwood.

Eucalypt regrowth in native pastures is best kept under control by burning. However, the frequency of being able to burn in the drier districts may be insufficient if the suckers and seedlings can reach more than 2 metres high. Care has to be taken if disturbing erodible solodic soils.

Brigalow regrowth can be controlled with herbicide or by blade ploughing.

Blade ploughing has the advantage of renovating run-down buffel grass; it is also economic because the land is more productive, and physically possible because there are no massive eucalypt stumps. However, current vegetation legislation also needs to be taken into account on all land types.

Broadleaf weeds (forbs)

There are numerous broadleaf weeds that can invade a rundown pasture; all compete with the grasses for water and nutrients, some like parthenium can cause allergies in humans, others like pimelea can poison cattle.

However, some others, besides the medics, may be eaten and can provide high quality 'herbage' in wet winters.

Broadleaf weeds can be controlled with herbicides but this is rarely economical. However, in one example, a well-timed herbicide spray killed all the weeds and promoted the growth of sown Bambatsi from nothing to thick grass one metre high within three months.

Again, the best protection from weeds is a vigorous pasture. Outbreaks of parthenium are most severe after pasture has been opened up after a drought.

Grass weeds

Grass weeds may be unpalatable native species such as white speargrass and wiregrasses (*Aristida* species) which are an indication of previous (or present) overgrazing. More serious can be introduced grasses such as Giant Rat's Tail grass (*Sporobolus* spp.) and African lovegrass (*Eragrostis curvula*). It is difficult to selectively kill one grass in a sward of other grasses but isolated plants can be spot-sprayed. Prevention by quarantining stock, vehicles or farm machinery that might be carrying seed of these grasses is the best system.

Pasture run-down

What causes pasture run-down

When a soil is cultivated, soil organic matter is exposed to the air. With seasonal fluctuations in moisture and temperature, the organic matter breaks down, and releases nutrients locked up with the organic matter.

Thus a pasture in newly cultivated land will grow vigorously, producing new leaf and expanding its root system. After a few years, the mass of new and dying fine roots help to improve the structure of the soil—that's one of the benefits of a pasture—but unless there is enough turn-over of new and old roots, the old roots and leaves continue to accumulate, locking up much of the protein. And buffel grass pastures are a special problem because buffel has a higher proportion of total growth in its roots than most other grasses.

Soil microbes get first call on any available nitrogen as they need it to digest material with high ratios of carbon to nitrogen. With less nitrogen available, the grass plant cannot grow as well as it did in the early years and it begins to show the normal signs of nitrogen deficiency—low production, small leaves, pale colour and less seed. The low protein levels in the leaf mean that the animals grazing the pasture do not grow as well as they did earlier on.

The pasture has run down.

How much nitrogen is there in the soil?

The total amount of nitrogen in a soil is surprisingly large; it can be as high as 11 tonnes per hectare (0.2% N) in a brigalow soil down to only 1.7 tonnes per hectare in a cypress pine-bulloak forest. However, nearly all of this is tied up in organic matter of some sort—such as plant roots and humus. Soil bacteria have the priority for any available nitrogen which they need to breakdown cellulose; less than 1% of the total nitrogen is available as a nutrient to plants.

Which pastures are most affected by run-down?

Native pastures have probably reached an equilibrium under conditions of low nitrogen over the eons, with the native species adapted to low nitrogen. They will respond to renovation but less vigorously than improved grasses on soils with higher nitrogen.

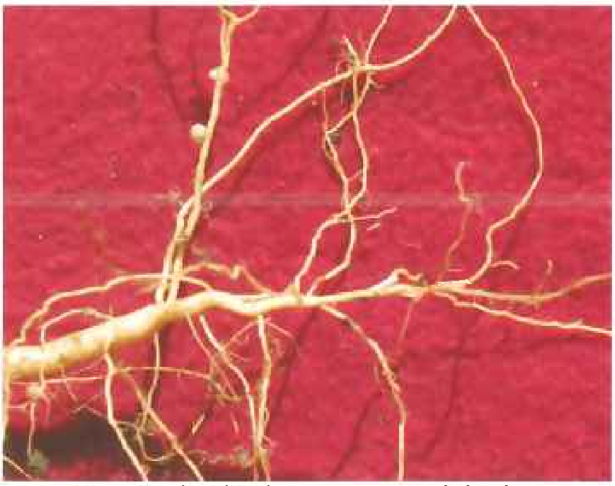
Run-down is seen mostly in improved grasses that have a high fertility demand. Buffel grass is particularly affected by rundown partly because of its demand for high fertility and partly because it has a larger proportion of its total growth in its roots. Whereas most grasses are around 50:50 tops and roots, buffel grass can have four times as much material making up its roots as in its tops. Buffel run-down is most visible on more marginal soils.

On some soils in the Roma area, severe run down has resulted in the buffel grass dying out and scalds developing.

Run-down buffel grass—pale leaf, open sward, poor seed production.

Run-down open weedy buffel grass in foreground. Renovated pasture in the background.

Severe buffel run-down resulting in the development of scalds.



Nitrogen fixed in legume root nodules becomes available to keep grasses vigorous.

How can I combat this declining production?

The effects of pasture run-down can be minimised by planting a legume with the grass or reversed temporarily by cultivating (renovating) the pasture.

Pasture legumes

Legumes fix nitrogen in nodules on their roots. Rhizobium bacteria in the nodules fix atmospheric nitrogen into protein which is used by the legume plant. The nitrogen is returned to the soil as the nodules decay, as the high-protein legume leaves drop or are eaten by grazing stock and then passed out as dung and urine.

With enough legume in the pasture, this cycle of nitrogen will keep the grass plants vigorous. With highly productive legumes such as leucaena, soil nitrogen can build up so that nitrogen-loving species (of grass or weeds) become dominant. Less productive legumes, such as Caatinga stylo and Desmanthus, may fix enough nitrogen to delay pasture run-down.

Blade ploughing releases nitrogen in the soil and increases water infiltration.

(Above) Buffel grass ploughed in late 2006.

(Below) Same paddock 16 months later.

Cultivation

Cultivation will increase water infiltration and, by exposing the old organic matter, will speed up the release of nitrogen.

The more severe the cultivation, the more effective the breakdown and release of nitrogen but also the greater death of uprooted pasture plants.

Blade ploughing to control brigalow regrowth will renovate buffel grass, but the cost is high. Seed of new pasture (and maybe Sugardrip sorghum or lablab) may be sown through a drum seeder on the blade plough. Ripping with tines or heavy discing will also give good renovation.

The benefits of blade ploughing come from the regrowth control whereas the economics from renovation are less certain as this benefit lasts for only a few years. With time, the nitrogen begins to get locked up in the grass roots again, and the run-down is repeated.

Complete cultivation can be associated with cropping. This will release nitrogen for one or more seasons of cropping before a new pasture is established. Establishment of the new pasture can be a problem after extended cropping because of weed competition.

Can I renovate by spraying or burning?

Spraying or burning will encourage old grass roots to slough off but there is less mineralisation as they are not disturbed and exposed to the elements and, on hard-setting soils, water infiltration is not improved without disturbing the surface.

Some graziers have found that spraying with glyphosate kills off the old buffel plants and allows hundreds of new seedlings to develop from the seed reserves. Chemical renovation is much cheaper than mechanical renovation using a blade plough but will not control regrowth of woody species. Aerial application of glyphosate can also reach land types unsuitable for cultivation.

Buffel renovation with glyphosate

Run-down buffel — small plants, poor colour, little seed production.

Aerial spraying with glyphosate can be used to renovate buffel country that cannot be blade ploughed.

Buffel killed with glyphosate

New buffel plants that have established from the mass of seed on the ground; note the vigour and colour.

The photographs of this page are used with the permission of Peter Thompson, Echo Hills, Wallumbilla.

Further reading and information

Pastures for protection and production on marginal cropping lands.
Proceedings of the Seventh Australian Tropical Pastures Conference held at Dalby, 11–12 April 2007, Tropical Grasslands, Vol.41, No. 3 2007.

Pastures for production, soil health and carbon sequestration.
Proceedings of the Eighth Tropical Pastures Conference held at Goondiwindi, 18–19 March 2009.

Grazing Land Management Producers Manual for the Condamine Catchment. George Lambert and Nikki Webb (2008), Condamine Alliance, Toowoomba, Queensland.

Grazing Land Management – Maranoa-Balonne Version (2005), Border Rivers Version (2009). MLA EdgeNetwork, Meat & Livestock Australia Ltd.

LeyGrain: Ley pastures in the Northern Grainbelt (Reference material and workbooks) (2006), Brian Johnson, David Lloyd, Susanne O'Brien, Rex Williams and Suzanne Boschma, DPI&F and GRDC.

Pasture Plants of Southern Inland Queensland (Reprinted 2007). D.R. Henry, T.J. Hall, D.J. Jordan, J.A. Milson, C.M. Schefe and R.G. Silcock, QI95016 Department of Primary Industries and Fisheries.

The Grasses of Southern Queensland (Reprinted 1996). J. C. Tothill and J. B. Hacker, Tropical Grassland Society of Australia, Brisbane.

Managing grazing in the semi-arid woodlands: a graziers guide.
Ian Partridge (1999). QI99075 Department of Primary industries, Brisbane.

Managing mulga grasslands: a graziers guide. Ian Partridge (1996) QI96072 Department of Primary Industries, Brisbane.

Managing mixed farms in the Maranoa-Balonne and Border Rivers, (2008) Grain & Graze and Department of Primary Industries and Fisheries, Brisbane.

Stocktake Database: Balancing Supply and Demand.
www.dpi.qld.gov.au/stocktake.

Rainman StreamFlow V 4.3. Department of Primary Industries and Fisheries, Toowoomba, Queensland.

Leucaena: a guide to establishment and management. Scott Dalzell, Max Shelton et al. (2006) Meat & Livestock Australia, Sydney.

The Leucaena Code of Practice

This Code of Practice is supported by Queensland Primary Industries and Fisheries and Queensland Parks and Wildlife Service. Those planting or planning to plant leucaena should heed these guidelines to ensure the plant does not become a weed threat. While the major weed threat is from ungrazed 'common' leucaena, commercial cultivars have similar weed potential.

- Do not plant leucaena in areas where river, creeks and flood channels can disperse seed pods or seed.
- Keep leucaena at least 20 metres away from external fence lines.
- Maintain a buffer strip of vigorous grass pasture between leucaena plantings and creeks or boundary fences.
- Graze or cut leucaena to keep it within reach of animals and minimise seed set.

Full details can be found at www.leucaena.net/codeofconduct.pdf

Pastures for Protection & Production describes how planting pastures on marginal cropping lands can protect the catchments of the Murray Darling in southern Queensland.

It is written in an easy-to-read question and answer style with all the points being made illustrated with colour photographs.

Pastures for Protection & Production has sections on:

- the environmental benefits of pastures
- restoration of soil carbon
- the problems with trying to restore land to its pre-settlement state
- sown pastures and selection of species
- establishing pastures on old cropping land
- managing the pasture
- recovery of run-down sown pastures.

The technical information has been based on presentations given at the 7th and 8th Australian Tropical Pastures Conferences held in 2007 and 2009 respectively. These conferences were organised by the Tropical Grassland Society of Australia.

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