Department of Employment, Economic Development and Innovation

Best-bet practices for managing the Mitchell grasslands of Queensland

A technical guide of options for optimising animal production, profitability and land condition

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Best-bet practices for managing the Mitchell grasslands of Queensland
A technical guide of options for optimising animal production, profitability and land condition

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Contents

1. Introduction

This technical guide is designed to help inform and improve grazing management in the Mitchell grasslands of western Queensland. It focuses on four major themes: managing stocking rate, spelling pasture, burning and developing the property with more fences and waters. The guide is a technical resource for use by those working with producers to improve the management of grazing lands for beef production.

The guide is a product of the Northern Grazing Systems (NGS) initiative which has been developed and implemented as a partnership between Meat and Livestock Australia (MLA), CSIRO, AgriScience Queensland (a service of the Department of Employment, Economic Development and Innovation), the Northern Territory (NT) Dept of Resources, and the West Australian (WA) Dept of Agriculture and Food. This initiative has been designed to ensure that the beef cattle industry in Queensland, the NT and northern WA derives the full benefit from research on how best to manage grazing country for beef production.

Other regional versions of this technical guide are available for the Victoria River District (VRD Northern Territory), Barkly (NT), and Maranoa Balonne, Fitzroy Basin and Burdekin regions of Queensland. Further planned versions include Alice Springs (NT), Kimberley (WA) and the Southern Gulf (Queensland).

The information in this guide has been derived from various sources, including a review of research reports, biological and economic modelling of management options, and the input of producers and technical specialists from each region.

The next phase of the NGS initiative, after the production of this technical guide, will continue to work with producers and their advisors in the region to increase awareness, understanding and uptake of improved grazing practices. The technical guide will be used to inform this activity and, over time, the guide itself will be improved by the information and experiences shared by producers, their advisors, and researchers. We welcome your feedback and to help improve this product.

2. How this guide was developed

This technical guide was developed by combining information from: 1. a review of research across northern Australia; 2. using a pasture and animal production model integrated with an economics model; and 3. expert knowledge and experience of producers and technical specialists from the region. In more detail, these were:

1. A review of reports from completed research on grazing land management relevant to northern Australia (Queensland, Northern Territory, and the northern rangelands of WA—Kimberley and Pilbara) which focused on four themes:

- managing stocking rate
- pasture rest
- burning and
- intensifying property infrastructure with more fences and waters.

2. Testing different management options using the GRASP and ENTERPRISE computer models to identify practices with the greatest benefits and narrow down the most cost-effective ways of implementing these practices. The GRASP model simulates and tests the effects of stocking rate, pasture rest and fire on pasture and animal productivity. Grazing trial data and pasture growth studies from the 1930s to the present time have been used to develop GRASP, which can be run for specific land types and over any sequence of years. The ENTERPRISE spreadsheet model assesses the economic returns of these practices, based on the pasture and animal productivity and management practices used in GRASP. The herd and paddock structure were typical of a beef enterprise within the region, based on expert knowledge from graziers, extension and research officers and consultants.

This testing of options provides:

- a way of extrapolating responses to grazing management measured in a grazing trial to a wider range of land types and climate conditions
- a way to test multiple variations in grazing management that would be expensive and time-consuming to test on the ground.

3. The combined knowledge and experience of producers and technical specialists from the region, including their assessment of the most relevant and useful outputs from the review of research and the modelling. This was captured over two workshops and direct input to reports including this Guide. This local input also helped develop plans for the next phase of the Northern Grazing Systems (NGS) initiative in the region and identified and prioritised information gaps.

Not all practices, or the many variations of these practices, have been objectively evaluated, and their impacts measured, in each region. Even where there is solid data on a practice, it often represents only one land type and a particular sequence of seasonal conditions. Furthermore, information from grazing trials or other sources of hard data needs to be considered in the context of the whole property. Local knowledge and experience combined with the biological and enterprise modelling have therefore been very important in helping form the guidelines and ideas in this Technical Guide. As there will be some degree of uncertainty about what practices will work best in any particular situation, it is important to see the guidelines and ideas as input to the decision-making process and not as set prescriptions or recipes.

3. Using this guide

The information in the Guide has been developed around four major issues common to most regions of northern Australia. These are:

1. How to best manage stocking rates over time to keep pasture in good condition and optimise beef production.
2. How to most cost-effectively recover pasture that has declined to poor (or ‘C’) condition.
3. How to deal with thickening or encroachment of woody plants.
4. How to most cost-effectively utilise ungrazed pasture that is distant from stock water.

For each issue, information is presented on:

- Signs (how the issue is expressed)
- Underlying causes
- Responses—the key practices and their rationale
- The specific management actions that can contribute to achieving better practice and the evidence-base for these.
- How to implement these actions.
- The trade-offs, caveats, uncertainties and other issues associated with this information.

The Guide is designed to be technical and detailed so that it captures the information, insights, ideas and uncertainties that arose from the research findings, modelling output and the views of producers and technical specialists in the region.

The Guide can be used by operatives working with producers in several ways:
1. As a means of improving their understanding of key grazing management practices and their awareness of the evidence base that underpins these practices.
2. As a source of ideas for management strategies that will most cost-effectively address a particular issue or objective.
3. As a guide to which issues, practices, and variations of these, deserve additional extension activity via demonstration sites or other processes.
4. As a guide to which issues/practices, and variations of these, require more research and/or on-property testing.
5. As a source of new information and examples for extension activities and information products, including EDGEnetwork Grazing Land Management (GLM) workshop materials.
6. As a means of capturing new insights and information from interactions with producers, property case studies and demonstrations, additional research, and additional biological and economic modelling.

4. Guidelines for grazing and fire management across northern Australia

This technical guide outlines best-bet management guidelines for common grazing management issues experienced in the Mitchell grasslands of Queensland. It draws on information from recognised literature sources, locally documented demonstrations and regional grazier experiences.

Within the Mitchell grasslands, stocking rate and pasture rest are the main management actions when managing land condition (Table 1). Infrastructure is important when addressing areas which are rarely grazed due to long distances from water and fire can be used to control woody plant problems (e.g. gidyea encroachment into open downs).

Table 1. Management factors than can be used to manage the four key issues in the Mitchell grasslands.

Issue	Management factor			
	Infrastructure	Stocking rate	Pasture rest	Fire
1. Managing good (A and B) condition country	(*)	***	*	*
2. Poor pasture condition	(*)	***	***	*
3. Woody plant problems		*	*	***
4. Ungrazed areas distant from water	***			

***—strong effect, **—medium effect, *—some effect, (*)—an interaction but not necessarily an effect.

These issues and management factors are common across northern Australia. The general guidelines that are applicable in the grazing lands of northern Australia are tabulated below (Table 2) and expanded upon in discussions at the regional level for each of the management issues.

How to recognise the signs and underlying causes of these issues within the Mitchell grasslands is summarised in Table 3.

This document draws on information from recognised literature sources, locally documented demonstrations and regional grazier experiences. The likely reliability and effectiveness of some these practices have been simulated with two different models run in conjunction: the GRASP model tested the ecological effects of management actions; and Enterprise tested the economic outcomes. The outcomes of these Bio-economic models are included. Gaps in information have been highlighted and are recommended for further research.

Table 2. Guidelines for managing issues in the grazing lands of northern Australia.

Principle 1. Use fences (paddocks) and water points to manipulate grazing distribution.

Guideline 1.1. Smaller paddocks and additional water points can achieve more effective use of pastures i.e. reduce the proportion of the paddock that experiences little grazing.

In the more extensive grazing areas of northern Australia producers should aim for: paddocks of 3–4000 ha (30–40 km^2) with two water points, and a maximum distance to water of about 3–4 km to strike a balance between improving grazing distribution and the cost of development.

For the more intensive regions in the eastern part of northern Australia, it is likely that paddocks of 2000 ha (20 km^2) with two water points are sufficient to optimise grazing distribution. Smaller paddocks may still benefit from sub-division where cattle show a strong preference for land types within a paddock.

To minimise the development of large sacrifice areas around water points the number of head per water point should be limited to no more than 300 head per water point.

Guideline 1.2. Smaller paddocks and additional water points do not overcome uneven utilisation by cattle at the plant community or patch scales. Other methods (e.g. fire, careful selection of water point locations) are needed to improve evenness of utilisation at these scales.

Guideline 1.3. Property development can generate significant increases in livestock production only where it results in more effective use of the pasture (increasing carrying capacity) as substantial improvements in individual livestock production are unlikely. If an undeveloped paddock is already operating at its long-term carrying capacity, paddock development may improve the sustainability of grazing through better grazing distribution.

Guideline 1.4. Fencing and water points can be used to help protect preferred land types and sensitive areas from overgrazing. Fencing to separate markedly different land types is an important strategy for controlling grazing pressure on preferred land types, and to get more effective use of all pasture resources on a property. It can be a practical option in some situations and should be considered where property development is planned
.

Principle 2. Managing stocking rates is vital to meeting animal production and land condition goals.

Guideline 2.1. Set stocking rates to match long term carrying capacity. Plan for the average paddock stocking rate to match its estimated long-term carrying capacity, as operating at or around the long-term carrying capacity will help maintain land in good condition. The extent to which stocking rates can exceed the long-term carrying capacity without reducing economic returns and/or reducing land condition is unclear.

Guideline 2.2. Regularly assess the need to adjust stocking rates in relation to current and anticipated feed supply and feed quality. Some variation in stocking rates over time is required to manage periods of below-average pasture growth. Capacity to vary numbers over time also provides opportunities to take advantage of periods of above-average pasture growth. The degree of variation that is most beneficial and achievable for different production systems is unclear.

Guideline 2.3. Management factors and issues other than forage supply also determine the need to vary livestock numbers. The adjustment of stocking rates over time should also consider land condition trend, ground cover, grazing pressure from other herbivores, and economic risk.

Principle 3. Rest pastures to maintain them in good condition or to restore them from poor condition to improve pasture productivity.

Guideline 3.1. Rest pastures during the growing season. As a rule of thumb commence the rest period after 38–50 mm of rain or sufficient to initiate pasture growth at the beginning of the growing season. If it is difficult to access country after rain then resting should commence before the wet season starts.

Guideline 3.2. Rest pastures for the whole growing season. Resting pastures for the whole growing season is likely to provide the most reliable benefit but most of this benefit appears to accrue from rest during the first half of the growing season.

Guideline 3.3. Pastures need two growing season rests to improve by one ABCD condition class. Pastures in B condition need rest for one or two growing seasons to improve to A condition. Pastures in C condition will need longer so plan on taking four good growing seasons to recover to A condition. Where growing conditions are poor, more rest periods will be required.

Principle 4. Devise and apply fire regimes that enhance grazing land condition and animal productivity whilst minimising undesirable impacts.

Guideline 4.1. Use fire to manage woody species. It may not be necessary to kill target species—topkill can be sufficient to alter the structure of woody populations. Mid-late dry season fires of moderate to high intensity are most likely to be effective in regulating the density and biomass of woody plants. Fuel loads are a critical issue—to reduce populations/biomass of woody species, a minimum fuel load of 2000 kg/ha is suggested.

Guideline 4.2. Use fire to change the composition of the herbaceous layer by killing plants, influencing recruitment or altering grazing preferences. Most research concerns the control of wire grasses in Mitchell grasslands and black spear grass pastures where fire is sometimes (e.g. coarse wire grasses in the Burnett region) but not always effective.

Guideline 4.3. Use fire to change grazing patterns by temporarily improving the attractiveness of previously ungrazed areas and providing rest to previously grazed areas.

Table 3. Key grazing land management issues for the Mitchell grasslands.

Issue	Sign(s)	Underlying cause(s)
1. Matching pasture supply to animal demand on land in generally good land condition	• Land is mainly in A or B condition. • There is generally ample feed for the whole year in good years, adequate feed in average seasons and inadequate feed towards the end of the year in poor years. Protein 'drought' is common in very wet years. • In drought, feed becomes inadequate and the risk of overgrazing increases. • Feeding protein supplements increases intake by 10-30% and needs to be considered in feed budgets. • There may be some overgrazed patches with low ground cover and the presence of less desirable species (C condition). • Continued overgrazing of C condition patches increases their size and number. Long-term overgrazing risks declining paddock land condition.	• Variability in pasture growth rates between years, during years and on different parts of the property. • Compounded by limited flexibility to vary cattle numbers within and between years; breeder enterprises have the least flexibility of all.
2. Managing pastures in poor (C) land condition	• Most of the paddock or preferred land type/s are in C condition. • There are still some preferred perennial grasses but they are widely spaced and may be small with low vigour. • Persistent patch grazing is occurring. • Ground cover is highly seasonal and generally poor towards the end of the dry season with substantial loss of moisture through runoff. • There is a high proportion of annual grasses, forbs or undesirable species. • Highly nutritious feed may be available for short periods after rain, but feed shortages can develop quickly in dry periods. • In drought, feed quickly becomes inadequate and the risk of overgrazing is very high.	• Drought and dieback events. • Flooding in excess of 1-2 weeks duration. • Chronic and sustained excessive grazing pressure. • Selective use of land type or area of paddock. • Can be exacerbated by intense wildfires. • Can be exacerbated on ashy soils.
3. Woody vegetation thickening	• Increased density of shrubs and trees, particularly on productive soil types. • Reduced pasture growth when woody vegetation is thick. • Encroachment into open land types.	• Sequences of very wet years. • Reduced competition from grasses due to heavy grazing. • Reduced frequency and/or intensity of effective fires.
4. Ungrazed pastures distant from water	• Significant areas of the paddock receive little or no grazing pressure.	• Inadequate number and/or location of water points in relation to paddock size. • Avoidance of land types with less palatable pastures or limited accessibility.

5. Current situation in the Mitchell grasslands

5.1. Land types and climate

The Mitchell grasslands are dominated by perennial native Mitchell grasses (*Astrebla* spp.) on generally treeless undulating clay downs. There are other country types associated with these downs, including timbered gidyea, boree and mulga woodlands, flooded country and spinifex sandplains. These other landtypes comprise approximately 30% of the Mitchell grasslands. This guide will focus on the open landtypes.

There are 16 recognised land types within the Mitchell grasslands (Whish, 2009) namely:

1. Open Downs
2. Ashy Downs
3. Pebbly Downs
4. Flooded Mitchell grasslands
5. Boree Wooded Downs
6. Wooded Downs
7. Soft Gidyea
8. Hard Gidyea
9. Hard Mulga
10. Soft Mulga
11. Soft Mulga Sandridge
12. Spinifex Sandplains
13. Jump-ups
14. Open Alluvia
15. Wooded Alluvia
16. Floodplains

These can be viewed on-line at the FutureBeef website or ordered on CD-ROM[1].

The Mitchell grasslands are predominantly within semi-arid to arid environments with high rainfall variability. Mean annual rainfall ranges from 200–550 mm. There is a distinct summer wet season, with the first summer rains generally starting in late December and finishing by May. The growing season usually lasts for 8–10 weeks during the summer.

[1] http://www.dpi.qld.gov.au/27_13350.htm

5.2. Land condition

Land condition is the capacity of land to respond to rain and produce useful forage; it is about productivity and sustainability. It relates to the potential to grow useful feed and is a good surrogate measure of ecosystem function. Land condition is classified into four broad categories: A (good); B (fair); C (poor); and D (very poor) condition.

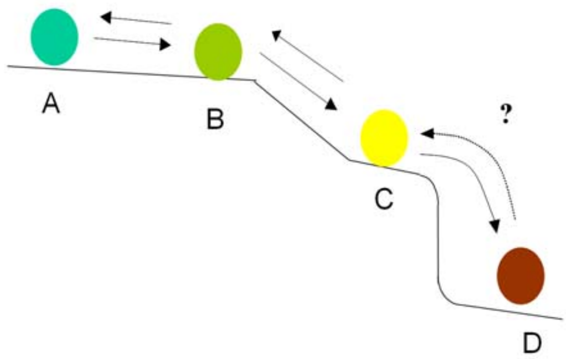
Land condition has three components:

- Soil condition: the capacity of soil to absorb and store rainfall, to store and cycle nutrients, to provide habitat for seed germination and plant growth, and to resist erosion.
- Pasture condition: the capacity of the pasture to capture and convert solar energy into green leaf, to use rainfall efficiently to conserve soil condition and to cycle nutrients; and
- Woodland condition: the capacity of the woodland to grow pasture, to cycle nutrients and to regulate groundwater.

Soil condition is assessed by the condition of the soil surface, infiltration capacity and amount of ground cover. Pasture condition is assessed by the types of perennial grasses present, their density and vigour. Woodland condition is measured by the tree basal area (TBA m^2/ha) and the balance of woody plants and pasture in different land types (Quirk and McIvor, 2003).

The ABCD land condition framework is a standard framework for measuring the grazing productivity and health of a grazing ecosystem across northern Australia. Much of the information about best-bet practices for grazing land management described in this guide will relate to the impact of those practices on land condition. More information about grazing land condition can be found in the EDGE*network* GLM and the Stocktake pasture monitoring workshop packages.

Moving between land condition classes is bit like a ball balancing on an incline, as shown on the right. A and B condition are not too far apart, and it does not take too much effort to return to A condition if your land has slid into B condition. However, it takes considerable effort to move from C to B condition. Improving from D to C condition takes a lot of effort and input, such as earthworks to halt erosion or chemical control of large areas of weeds.



Observations in 2006 indicated that approximately 40% of the open Mitchell grass land types are in good (A or B) condition, 50% in C condition and 10% in D condition (Phelps *et al*. 2007). Most of the D condition country in the Mitchell grasslands is due to the invasion of prickly acacia (*Acacia nilotica*). Direct observation suggests the area of scalded, patch-eroded D condition land is increasing within riparian areas and on ridges.

For the Mitchell grasslands, land condition (Table 4) is based on:

1. The density and yield of 3P grasses (perennial, palatable and productive, such as Mitchell grass and blue grass), presence of weed species and ground cover (the pasture condition).
2. Un-eroded, healthy soil (the soil condition).
3. Retaining ‘natural’ tree and shrub density and structure (the woodland condition, Chilcott *et al.* 2002).

Table 4. Summary land condition characteristics for Open Downs.

A CONDITION (GOOD) HAS THE FOLLOWING CHARACTERISTICS:

- A Mitchell grass tussock every 0.8–1.2 m (high plant density)
- Pasture with a mix of other plants—generally of high grazing quality
- Maximum pasture growth and response to rain
- Rated at 100% of the long-term carrying capacity
- No weed infestations
- No erosion
- Good soil surface condition
- Generally good ground cover (less than 30% bare ground)

B CONDITION (FAIR) HAS THE FOLLOWING CHARACTERISTICS:

- A Mitchell grass tussock every 2–3 m (moderate plant density)
- Pasture with a mix of less-favoured or annual plants
- Pasture growth and response to rain reduced by 25%
- Rated at 75-80% of the long-term carrying capacity
- May have some weeds
- May have some signs of erosion
- Generally good soil surface condition
- Generally good to moderate ground cover (30-60% bare ground by the end of the dry season)

C CONDITION (POOR) HAS THE FOLLOWING CHARACTERISTICS:

- A Mitchell grass tussock every 20–30 m (low plant density)
- Pasture dominated by less-favoured, unpalatable or annual plants
- Pasture growth and response to rain reduced by 55%
- Rated at 45% of the long-term carrying capacity
- May have weed infestations
- May have obvious signs of past erosion and/or declining soil surface condition
- Generally moderate to poor ground cover (often more than 60% bare ground at the end of the dry season)

D CONDITION (DEGRADED) HAS THE FOLLOWING CHARACTERISTICS:

- Almost no Mitchell grass tussocks
- Pasture based on less-favoured, unpalatable or annual plants with little to no Mitchell grass
- Pasture growth and response to rain reduced by 75%
- Rated at 25% of the long-term carrying capacity
- Will often have weed infestations
- Will often have obvious signs of erosion or scalding, resulting in hostile environments for plant growth
- Moderate to poor ground cover (generally more than 60% bare ground by the end of the dry season)

In the open Mitchell grassland land types, spacing of Mitchell grass tussocks is a key indicator of land condition. The soils, being self-mulching clays, are generally resilient and rarely show signs of erosion. These land types are open in nature and so there are generally no significant impacts of tree basal area. The wooded land types, especially gidyea and boree, can have high tree basal area which impacts on pasture growth and hence productivity. Gidyea is an invader of open downs land types.

As a guide, A condition country has a tussock every 0.8–1.2 m (high plant density), B condition 2–3 m (moderate plant density) and C condition 20–30 m (low plant density). Mitchell grass tussocks are generally absent in D condition country, although there may be isolated clumps or scattered tussocks. This guide must be tempered with the contribution that Mitchell grass and other 3P grasses are making to the pasture at the time of the assessment. A moderate to high abundance of weeds in the pasture precludes it from being in A condition, even if the tussock spacing is 0.8–1.2 m.

Allowances need to be made for lower rainfall areas, such as the Boulia district or Mitchell grass pastures within the channel country. Lower tussock spacing of two for four times the distance between tussocks—as a reasonable guide—is expected in these areas. Lower tussock spacing of about twice the distance between tussocks should also be expected in lower fertility soils, shallower soils, Ashy and Pebbly Downs. In wooded land types the distance between tussocks under A condition can be as much as 4-5 m although Mitchell grass may be present as isolated clumps of high density. Stony land types within the channel country may have barley Mitchell grass confined to run-on patches within an other-wise stone covered annual herb-field.

Assessing land condition in areas where prickly acacia is starting to spread is problematic. If there are isolated seedlings, or young trees up to 1–1.5 m height, and the pasture and soil is intact, then the land may still be as productive as A condition—but it is on a fast slide into B condition. A high percentage of weeds in a pasture precludes it from being in A condition. There are situations where the pasture is still healthy with a scattered over story of mature prickly acacia. This is not A condition. If the Mitchell grass tussock spacing is still in the order of 1.2–3 m, then it is B condition—but it is on a fast slide into C condition. Less than this and the area is already in C condition and sliding towards D condition.

Areas where prickly acacia has established as dense stands are usually clearly in D condition. Despite the resilience of the heavy clay soils, there is often obvious erosion in conjunction with these dense stands.

Assessing Land condition in Mitchell grass country during drought is also problematic. The land will rarely be in A condition during drought, as two to three wet seasons, or an exceptionally above average wet season, are needed to restore Mitchell grass tussocks to full health (a high basal area). D condition land is relatively easy to assess, as there will be no sign of Mitchell grass tussocks, and the landscape will be generally dominated by bare ground or short lived species.

The most difficult situation to assess is where there is a high density of grey or blackened drought-affected Mitchell grass tussocks with no signs of shoots due to the lack of rain. Tussocks need to be inspected to see if they still have live groups of tillers capable of responding to rain, or if completely dead. The 'tussock tug' guide developed by DEEDI in 2005 for the Mitchell grass dieback project can be used to assess if the majority of tussocks are alive or dead. If alive, then land is in B condition. If dead, then it is in C condition.

It is possible during drought for sparse Mitchell grass tussocks to be present and alive, and responding to the limited soil moisture available. There will be few, if any, other plant species present so Mitchell grass will dominate the yield. This is still C condition, even though the predominant contributor to yield is a 3P grass. A dense stand of fragile Mitchell tussocks e.g. tussocks spaced at 1–2 m, but with only one tiller emerging following rain, will be in B condition and at high risk of slipping into C condition if stocked at a high grazing pressure relative to the limited feed on offer. Tussock spacing generally over-rides yield contribution in Mitchell grass country as the determinant of pasture condition. For example, during the drought recovery phase roly poly (*Salsoli kali*) can dominate pasture yield. Where there is high density of low yielding—but healthy—Mitchell grass tussocks the land is in B condition and at a high risk of slipping into C condition.

Land in that remains in good (A or B) condition during drought has a much better prospect of recovery than country in poor (C) condition. For instance, recordings made at 49 key sites across western Queensland during drought in 2006 showed there were more live plants, more seedlings and more seed in the soil at sites in A or B condition than in C condition (Table 5). There were more dead plants under C condition. The trend was similar following better than average rain in 2009, although most of the old dead Mitchell grass plants had rotted and washed away by then.

Table 5. The relationship between good (A and B) and poor (C) land condition and living or dead Mitchell grass plants, seedlings and seeds in the soil during and following drought. The recordings were made at 49 key sites across western Queensland.

Mitchell grass measurement	***A condition***	***B condition***	***C condition***
During drought in 2006			
Live Mitchell grass plants (plants/m^2)	5.1	2.4	0.4
Dead Mitchell grass plants (plants/m^2)	0.5	1.1	1.7
Mitchell grass seedlings (plants/m^2)	4.3	2.9	0.5
Mitchell grass seeds in the soil (seeds/m^2)	216.4	159.9	32.2
Following drought in 2009			
Live Mitchell grass plants (plants/m^2)	6.0	3.5	0.6
Dead Mitchell grass plants (plants/m^2)	0.1	0.5	0.3
Mitchell grass seedlings (plants/m^2)	0.3	1.8	0.6
Mitchell grass seeds in the soil (seeds/m^2)	14.3	5.0	0.0

5.3. History of grazing use

Western Queensland was opened up for pastoralism in the late 1860s, with most of the suitable lands grazed under private ownership by the late 1880s. Severe and extended drought in the late 1890s through to 1902 saw many properties change ownership and a search for more reliable water supplies. Drilling for water became common by the 1920s, with flowing water suitable for stock discovered at depth in the Great Artesian Basin. As water became more reliable, government settlement schemes created smaller properties from the large private company holdings that had dominated ownership for the first 40–50 years.

Wool production from medium-micron Merino sheep run on family-operated properties dominated the pastoral industry until about 1995, with a peak of sheep numbers and production in the 1950s. This was in response to high wool prices. Severe drought in the 1960s and low wool prices in the 1970s led to lower sheep numbers. The wool enterprise was based on a core flock of breeders to ensure natural replacement of sheep as they were culled and sold. Between the 1960s and late 1990s sheep prices were generally lower than the cost of transport of sheep to market—often leading to delays in de-stocking.

Cattle prices were also low during the 1970s and graziers struggled to find the best mix of livestock enterprises for the Mitchell grasslands. By the early 1980s, however, the northern Mitchell grasslands (e.g. Julia Creek and Richmond districts) were starting to be dominated by cattle production—generally breeding operations—but with some backgrounding operations.

Strong beef and cattle prices in the late 1990s, coupled with low wool prices, hastened the decline in sheep numbers, with wool growing being replaced by cattle enterprises. By 2010, very few wool sheep remain north of Longreach. Some graziers have substituted meat sheep breeds such as Damara and Dorpa or goats for the wool producing Merino.

The increase in cattle numbers was coupled with increasing number of property sales and increasing land prices as many wool producing families sought to exit the industry when offered good prices. In many cases, third or forth generation wool producing families exited the region completely—also taking their skills and experience of land management with them.

Land values now generally exceed the capacity of the country to pay back debt based on production alone. Sales since 1999–2000 have included a high value for grass, as northern and eastern cattle producers have bought land rather than agist their stock. In the order of 30–40% of current (2010) land values would be based on speculation of increased property values. Land prices eased towards of the end of the 2001–2009 ‘Millennium’ drought.

The majority of land managers took advantage of relative high livestock prices at the onset of the 2001–2009 ‘Millennium’ drought, selling up to 60% of their stock over a two year period. The key reasons for these sales were to prevent crisis feeding, prevent stock deaths and to retain ground cover to preserve future productivity. Such aggressive early de-stocking has not been documented historically in the Mitchell grasslands, with most de-stocking occurring progressively as drought continues. Unfortunately the de-stocking did not prevent the wide-spread drought induced death of Mitchell grass. The failure of the de-stocking management strategy is perplexing and the subject of other investigations (Phelps *et al*. 2007).

5.4. Property development with fences and waters

Infrastructure is continuing to change from that needed for sheep production to cattle production. This means the loss of shearing sheds, the conversion of low-set stock troughs or bore drains to higher-set troughs for cattle access. Fences have changed from five plain and one barb wire or netting to more cost effective three barb or similar designs.

It was common practice for water to be reticulated from a flowing bore through open bore drains from the 1920s onwards. However, the issue of high evaporation from bore drains and a subsequent loss in pressure, water flows and water levels in the Great Artesian Basin was recognised by the 1980s. Government schemes to phase out bore drains in preference for piping water to tanks and troughs have been in place since the late 1980s. The altered water placement has changed the pattern of grazing use from linear piospheres (areas of grazing impact around waters) to point piospheres. Unfortunately, the replacement of bore drains has not included planning of the optimal placement of water for livestock access within paddocks.

5.5. Stocking rate management

Stock numbers are generally adjusted as feed becomes scarce. The lack of browse from trees or shrubs in Mitchell grass country means that the pasture is the only natural source of fodder. The only options once the pasture starts to become limiting are destocking, supplementary feeding or substitution feeding.

Breeding enterprises often have limited options compared with Merino wether or cattle backgrounding enterprises, which rely on buying and selling rather than natural increases and decreases.

Total grazing pressure is an important consideration in the Mitchell grasslands, with many areas having large populations of kangaroos. Eastern grey kangaroo numbers have increased since the 1960s and wallaby numbers more recently, as water sources have become more reliable. Kangaroos are now in high densities, especially in country that offers both shade and water, and comprise a significant proportion of the grazing pressure on the landscape. Red kangaroos were present at the start of pastoralism—there is no firm evidence for an increase in their numbers. Localised areas have populations of wallabies, wallaroos and euros in high densities. Grazing pressure can be high in localised areas from feral goats and to a lesser extent from feral pigs.

5.6. Pasture rest

There is considerable interest in pasture rest, but few graziers use it as a defined management tool. Historically, land holders have practiced opportunistic rest, but generally not as part of a strategy. A key problem in implementing pasture rest is uncontrolled grazing from kangaroos, especially in—or adjacent to—wooded land types.

5.7. Grazing system

Rest has been incorporated through newer grazing systems across northern Australia since the mid 1990s. Several graziers within western Queensland have implemented cell and holistic systems. Some have been successful whilst others have not. Successful implementation incorporates: the flexibility to adjust to highly variable rainfall and pasture supplies; matching stocking rates with the inherent carrying capacity of the land; and using pasture rest to ensure A to B land condition across the property. These principles are the same as for continuous grazing. Research in Queensland has found that the extra training, knowledge and observations of pastures and livestock when changing to these more intensive systems are the recipes for success, rather than the actual grazing system itself (Hall *et al* 2011)

5.8. Prescribed burning

There is very little interest in using fire as a management tool in the Mitchell grasslands. Potential roles of fire include control of thickening gidyea and boree on wooded land types, control of encroaching gidyea and boree into open land types, restoring B/C condition country dominated by feathertop wiregrass to A condition, the removal of moribund pasture to improve grazing, and as a wildfire suppression and management tool. However, the problems with patch burning attracting high grazing pressure from kangaroos with associated high risks of land degradation, the high value placed on standing dry feed as a drought reserve and the historically bad experiences with wildfire (especially during the 1950s) discount the potential benefits for most land holders.

As a result, management of fire is basically limited to the suppression of wildfire during seasons of adequate fuel load.

5.9. Current issues and trends

In 2012 the Mitchell grasslands face the issues of:

- A loss of practical expertise and knowledge of natural resource management through the exit of multi-generation land owners.
- A high proportion of cattle graziers with less than 10 years experience in managing Mitchell grass country.
- Increasing pressures to repay debt—generally leading to increases in cattle numbers on individual properties.
- Increased total grazing pressure from kangaroos and feral animals.
- Established weeds such as prickly acacia, Parkinsonia and mesquite.
- Emerging weeds such as Parthenium and sticky Florestina.
- Wildfires in late 2011—and a high risk for 2012—due to lightning storms and a lack of experience in managing pastures for wildfire recovery.
- Flood damage to pastures and a general lack of scientific knowledge of the potential impacts and post-flooding management.
- Uncertain rainfall trends under climate change
- Rehabilitation of D condition lands such as scalded .areas and areas where prickly acacia has been removed.

Weed control and rehabilitation of D condition lands are not addressed in this guide.

6. Best-bet management of the Mitchell grasslands

6.1. Matching pasture supply to animal demand on land in generally good condition

When land is generally in good to fair condition (A to B), the main issue centres on managing feed supply to be profitable and to maintain good land condition. Whilst there is generally ample feed in good seasons and adequate feed in average seasons there is usually inadequate feed in poor seasons. There may be a few overgrazed (C) condition patches that also require attention. The essential management actions are matching stocking rate to long term carrying capacity and using forage budgeting to adjust stocking rate to seasonal conditions. These should be complemented by spelling and possible prescribed burning.

About 40% of the Mitchell grasslands are in A or B condition, based on surveys conducted during 2005 and 2006. A major challenge facing managers is how to optimally use the associated good feed production for animal production, while at the same time maintaining land condition. High stocking rates increase pasture utilisation. In good years this can increase animal production per hectare, but in poor years high stocking rates can give poor production per head and degrade the pastures.

The amount of feed grown each year varies widely due to high rainfall variability. The appropriate number of animals to utilise the feed also varies widely. In theory, it would be desirable to change animal numbers each year so that the feed demand by animals matches the feed supply from the pasture. In this way, overgrazing and subsequent pasture deterioration during periods when pasture growth is low is avoided, and animal production increases in years with high pasture growth. However, this is not simple as the feed supply is not known in advance, and there are limits to how much animal numbers can be altered particularly in a breeding enterprise. For instance, in a long-term grazing experiment at Toorak Research Station, Julia Creek, short term carrying capacity ranged from 0.2 up to 2.5 dse/ha[2] to achieve the desired safe 22% utilisation rate based on feed supply (Figure 1). This represents large fluctuations in livestock numbers which are beyond the capacity of land holders to implement.

[2] A dse is one dry sheep equivalent, or 0.11 of an adult equivalent (AE)

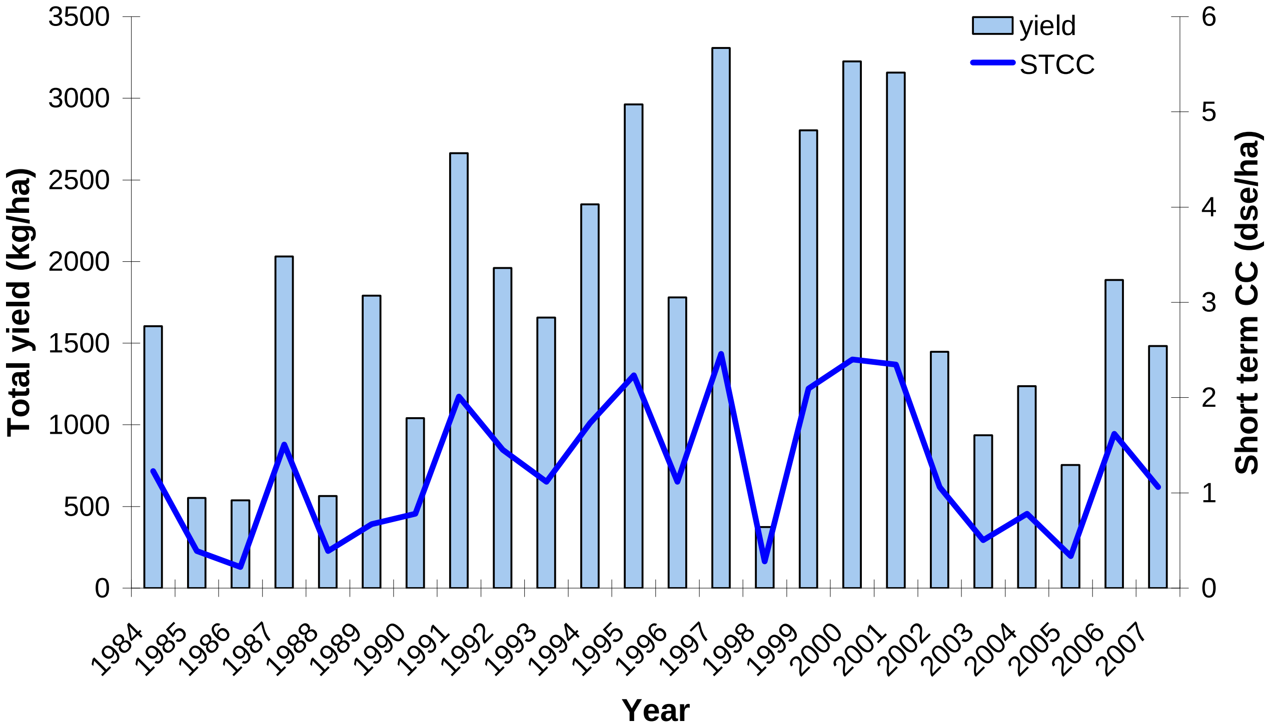


Figure 1. Large variations occur in short-term carrying capacity (STCC) when attempting to match stock numbers with feed supply.

6.1.1. Signs

The pastures in this scenario may have some overgrazed patches with low ground cover and some less desirable species but are generally in A/B condition. However, any overgrazing is likely to lead to the patches increasing in size and frequency and if continued for a longer period it is likely that land condition will decline.

Feathertop (*Aristida latifolia*) can dominate some areas, especially following a series of summers with above-average rainfall. This is generally in low B condition, as Mitchell grass plants are usually still abundant. Mitchell grass growth is suppressed by up to 70% due to the competition from feathertop, discounting land condition down from A. If Mitchell grass plants have thinned out markedly and 3P yield is reduced then land condition has declined to C.

6.1.2. Causes

Pasture yield changes faster than it is possible to adjust stock numbers in many situations—especially in summers with above average rainfall following a series of below average seasons. High variability in pasture growth is mainly linked to the high variability of rainfall in western Queensland but other factors such as humidity, cloud cover and soil Nitrogen availability also drive pasture growth. Pasture growth rates can vary widely both between years and during years and is the major cause of mismatches in feed supply and demand.

6.1.3. Management response: improve stocking rate management supplemented by pasture spelling

Although changes in growing conditions are a major cause of mismatches between feed supply and demand, they are largely outside the control of managers and the most important management response is to adjust stocking rate.

There are two broad approaches. The first approach is to consistently stock at a relatively low level so that the level of pasture utilisation is not excessive in any year (or at least most years). This approach avoids overgrazing in poorer years but forgoes the extra animal production that could be achieved in better years and hence may incur a financial penalty. The second approach is to adjust animal numbers so that animal demand is less than or equal to current and/or anticipated future feed supply. This should minimise periods of overgrazing and feed deficit while making good use of feed in above-average years. This can result in higher overall utilisation of feed but there is a risk of overgrazing if animal numbers are not reduced quickly enough when pasture supply is low.

Pasture resting—or spelling—can also be used to alter the pasture supply and when it is consumed. In limited circumstances, fire may assist in changing grazing patterns to prevent patches increasing. Increased kangaroo grazing pressure on burnt patches and high rainfall variability are constraints to the use of fire for most of the region.

6.1.4. Management action: match stocking rate to long-term carrying capacity

A risk-averse approach has generally proven to be a successful long-term approach to managing stocking rates in western Queensland. Stocking at close to the long-term carrying capacity (equal to or less than 22% average annual pasture utilisation depending on land type) of the land in most years is generally the most profitable in the medium to long term and the least risky (economically and ecologically) approach to managing stocking rates. The focus should be on maximising profit per hectare in the long term. Maximising production per hectare is not necessarily the way to maximise profit.

High stocking rates in excess of the long-term carrying capacity (e.g. annual pasture utilisation rates greater than 22% for the more productive land types) may be more profitable in the short term but are less profitable over the longer term because of the effect of drought years and declines in land condition and productivity. Maintaining high stocking rates during drought risks causing marked land degradation that can reduce production for years after, or increase subsequent yearly variability in production. High stocking rates (especially on poor condition land or in poor seasons) can mean cattle will be subject to weight-for-age penalties at market or increase supplement costs, both of which can reduce profit. Conversely, consistent under-stocking may reduce profitability.

The safe pasture utilisation rate concept and historical rainfall and pasture growth data for different land types can be used to develop an understanding of the long-term carrying capacity of the land (see GLM workshop manual, Chilcott *et al.* 2002). Safe pasture utilisation rates tend to be lower in less productive regions (e.g. lower annual rainfall, shorter growing season, less fertile soils) and where annual rainfall is more variable. A more conservative approach to setting stocking rates is required in such regions.

6.1.4.1. Evidence

There have been many experiments over more than 70 years examining stocking rate or utilisation responses. Most of these have been in Queensland (both east and west), with some in the NT and WA. As a general rule they show declines in pasture condition as annual utilisation rates exceed approximately 30%. Expert knowledge has been used to develop recommended safe utilisation rates for land types in northern Australia.

Looking further abroad, there is a large body of international and Australian literature showing that animal production per head declines linearly as stocking rate increases and animals compete with each other for quality feed (Figure 2a; Jones and Sandland 1974). Production per hectare increases initially, as the lost production per animal is compensated by the higher number of animals. A per hectare ceiling is always reached, however, as animals become weakened and are unable to grow adequately and/or mortality rates increase. Live-weight gain per hectare is generally maximised beyond the point at which profits are maximised. A further implication of this is that declining livestock condition and/or declining per hectare production may be poor indicators of profitability (Figure 2b).

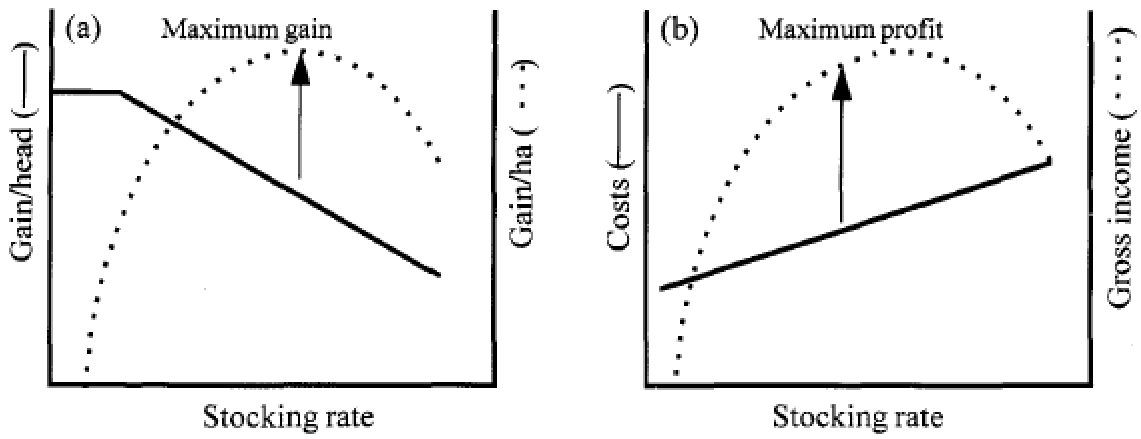


Figure 2. (a) The Jones-Sandland model relating livestock performance to stocking rate. (b) the relationship between stocking rate and economic performance based on the Jones-Sandland model (from Ash and Stafford Smith 1996).

Ash and Stafford Smith (1996) have demonstrated that animal production in rangelands is less sensitive due to the much greater spatial and temporal variability of rangelands. It is also likely that the optimal stocking rate varies with above and below-average rainfall in the rangelands.

The Wambiana grazing experiment at Charters Towers (O'Reagain *et al*. 2009; 2011) showed that over a 13 year period, constant moderate stocking (approximately 25% utilisation) gave better financial returns and pasture condition than constant heavy stocking (approximately 50% utilisation). Heavy stocking gave very good returns during years of above average rainfall but this was offset by high costs of drought feeding during poor seasons. Heavy set stocking also led to poor pasture condition. The accumulated gross margin under heavy stocking rates was consistently worse than moderate stocking or flexible stocking approaches once land condition declined (Figure 3).

The steer stocking rate trial at Rosebank Research Station, Longreach, demonstrated that high stocking rates could drive land condition from A/B to C within six years (D. Jackson pers comm). A moderate stocking rate of 1 AE to 10 ha (25 acres) maintained land condition and steer production. Further work is needed to estimate the utilisation rates imposed in this trial using the GRASP model.

Sheep grazing over 25 years at Toorak research Station, Julia Creek, was sustained at a moderate grazing pressure (an estimated 22% average annual utilisation) with no reduction in land condition. Heavier grazing pressure (in the order of 35–45% average annual utilisation) led to patch-degradation after 20 years of continuous grazing. In contrast, very heavy grazing pressure (in excess of 65% average annual utilisation) coupled with full wet season spelling and drought de-stocking allowed for recovery from reduced land condition (Orr and Phelps 2004). This suggests it may be possible to couple regular pasture spelling with higher grazing pressure without adverse effects. This concept requires testing before it could be recommended as a management approach.

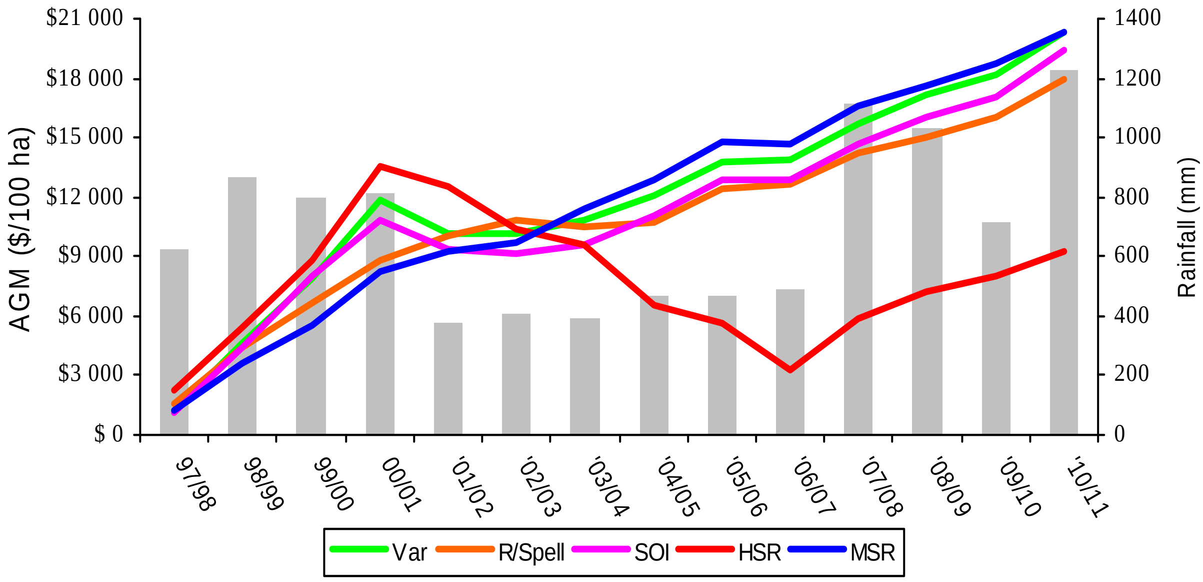


Figure 3. Accumulated gross margin (AGM) for five grazing strategies from 1997–98 to 2009–10 (assuming an interest rate of 7.5 % on livestock capital)[3]. From O'Reagain *et al*. 2011

These observations are supported by the results of the Mt Sanford and Pigeon Hole trials in the Victoria River District (VRD) of the NT. Despite declines in individual animal performance at Mt Sanford, earnings before interest and tax (EBIT) per unit area were higher in the high utilisation rate paddocks due to increased turnoff (Hunt *et al*. 2010). This was a direct result of a run of above-average rainfall years. Production results after the one poor wet season of the trial (2002/3) indicate that the higher utilisation rates were not environmentally or economically sustainable. Weaning percentage declined at higher utilisation rates after the poor wet season and took two years to recover (Hunt *et a*l. 2010). Production was also more variable through time at higher utilisation rates. Production indices that performed better at lower utilisation rates included breeder weight, inter-calving interval and kilograms of weaner produced per unit area (Hunt *et al*. 2010). Thus, breeder herds in the VRD can maintain high weaning rates at high utilisation rates provided seasonal conditions are favourable. However, once seasonal conditions deteriorate, breeders may be unable to maintain calf output, resulting in lower weaning rates.

In the Pigeon Hole trial, there was a 14% decline in individual animal production with a doubling of utilisation rate (Hunt *et al*. 2010). Like at Mt Sanford, however, the decline in per head production was offset by increased per hectare production (and thus profit) at higher stocking rates. Inter-calving interval, steer live-weight gain, branding rate and weaning rate were not correlated with utilisation rate. Only weaner weight (which directly influences weight weaned per hectare) responded to utilisation rate at Pigeon Hole (Hunt *et al*. 2010). At a utilisation rate of 13%, the proportion of cows pregnant and lactating was slightly higher, and calf losses were lower than at higher utilisation rates. So, whilst there appeared to be little

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[3] Where: R/Spell is rotational wet season spelling coupled with moderate-heavy stocking; HSR is heavy stocking at twice the long-term carrying capacity (LTCC) of the site; MSR is moderate stocking at the LTCC; VAR is variable stocking with stocking rates adjusted annually in May based on forage availability; and SOI is a variable strategy with stocking rates adjusted annually in November according to forage availability and the Southern Oscillation Index (SOI).

production penalty in implementing higher stocking rates over the relatively good seasons experienced during the trial, the lower weaner weights may have a hidden cost in that turn-off times for steers may be longer and heifers may take longer to reach joining weight. Furthermore, the negative impacts on land condition described above would be expected to have negative production impacts over the longer term—particularly during poorer seasons. In the Pigeon Hole trial, stocking rates were adjusted to reflect the forage supply in May each year. This annual adjustment of stocking rate to track forage supply is likely to have dampened the impacts of higher utilisation rates on animal performance compared to a set-stocked regime at similar stocking rates (R. Cowley pers. comm.).

The VRD results support the findings of the Wambiana trial in Queensland (O'Reagain *et al*. 2009; 2011) where over a 13 year period, constant moderate stocking (average 25% utilisation) gave better financial returns and pasture condition than constant heavy stocking (average 50% utilisation). The latter gave good returns during the early years of the trial, which experienced average to above-average pasture growth but not during subsequent poor seasons when returns were very poor. Heavy stocking also led to poor pasture condition and an ongoing penalty to production—especially in years of limited soil moisture.

The long term grazing study at Toorak gave similar sheep performance and economic results with to the cattle results in the NT and at Wambiana. Wool production per ha was initially better under higher stocking rates despite lower wool cuts per head—simply because of the higher sheep numbers. Once land condition began to decline under higher grazing pressure and high sheep numbers could no longer be sustained, wool production per ha and economic returns also declined. Preliminary economic analysis suggests that moderate grazing pressure (approximately 22% utilisation) achieved the highest returns.

6.1.4.2. Implementation

While the concept of setting long-term carrying capacities using appropriate utilisation rates for each land type is sound, its application is complex, requiring knowledge of average pasture growth rates for different land types on a property and their safe utilisation rates. Most land managers don't have ready access to either the information or concepts and systems unless they attend an EDGE*network* Grazing Land Management (GLM) or Stocktake workshop.

Long term carrying capacity can be estimated across land types within paddocks using the GLM EDGE*network* approach (Chilcott *et al*. 2002). Land type and location specific pasture growth tables are coupled with estimates of land type area, safe utilisation rates, tree basal area and land condition. This requires paddock scale mapping, descriptions of land types, and estimates of land condition and tree basal area. GLM workshops offer the training required to use this approach.

Livestock numbers are adjusted around the long term carrying capacity as rainfall and pasture growth vary, to approximate the safe utilisation rate.

Long term carrying capacity is a useful tool at the property scale in western Queensland. Used since the mid 1990s in delivering safe carrying capacity estimates (Johnston *et al*. 1996) through property advisory visits and GLM workshop planning sessions, over 500 properties have long term carrying capacities. These are estimated by coupling property rainfall with mapped land type areas to calculate pasture growth within paddocks. The safe utilisation rate of the land types is then used to benchmark the average carrying capacity in the long term at the paddock and property scale. The range of computer mapping programs now available makes these calculations simpler for any land holder to achieve.

The benchmarked long term carrying capacity is a useful figure to adjust stock numbers up in above average and down in below average seasons. Forage budgeting should be used to adjust stock numbers around the long term carrying capacity.

The technique provided in the GLM and Stocktake workshops offer an objective assessment that is repeatable, uses local climate information and can account for changing conditions such as declining land condition and woodland thickening. The comparative outputs of these assessments can then assist in determining the profitability of a range of management strategies to improve the situation.

The first thing to do is to check land condition and tree densities of the different land types in each
paddock. Use the Stocktake and GLM approach of checking the presence or absence of 3P grasses and their health, presence of weeds, any signs of erosion or abnormal hard setting soil surfaces and measuring the basal area of existing woody vegetation. If the land condition is good then historical stocking rates and management have been sustainable and can be maintained.
If there appears to be a decline in land condition to B, then reassess carrying capacities using GLM or Stocktake techniques. Compare the outcomes with current stocking rates and adjust stock numbers if necessary.

Where there are contrasting land types in a paddock and grazing is concentrated more on one land type than another, fencing out the overgrazed land type should be considered as an option for avoiding further declines in land condition. Using the safe carrying capacity technique described above can show the benefits to production but these results should then be tested in a suitable economic package such as ‘Breedcow Dynama’ or ‘Testing Management Options’.

The safe CC calculations given in the GLM workshop can provide an objective assessment of carrying capacities to consider in conjunction with local recommendations. These calculations require pasture growth data for each of the land types on the property, their safe utilisation rates and an estimate of annual pasture intakes by the classes of stock grazing each paddock.

The Stocktake database shortcuts these manual calculations to some extent and will calculate current and potential carrying capacities of land types and paddocks once information on land condition and tree densities is entered.

An important consideration is to allow for grazing pressure from feral and native herbivores that may be present when setting stocking rates. Kangaroos and wallabies can consume a high proportion of pasture on offer when present in large numbers, so they need to be taken into account or numbers managed. On average, 14 kangaroos will eat as much pasture on a daily basis as a 450 kg steer or dry cow.

Also discount the stocking rate according to the area of a paddock that is not accessible from water. This will include areas too steep or rocky for stock to access or areas more than 3 km from water.

Monitor pastures and woodlands so any resulting changes in pasture growth can be accounted for.

6.1.4.3. Considerations/caveats

The long term carrying capacity is not an upper or lower limit and is rarely the actual stocking rate desired to achieve sustainable productivity. It requires active management to achieve. Consistently stocking at the long term carrying capacity results in reduced land condition as it is too high under drought conditions.

Long term carrying capacity estimates allow for a modest level of grazing by kangaroos, goats and other animals that are not readily managed.

Early safe carrying capacity estimates conduced within western Queensland did not account for inaccessible areas within paddocks due to long distances from water points.

Implementation of stocking rates in the long term grazing study at Toorak has shown that large annual variations in numbers can be required even at very low grazing pressure (10% pasture use). Large reductions in sheep numbers—in excess of two fold—were necessary in the dry years of 1985, 1988, 1992, 1998 and 2003 (Figure 4). Large increases were necessary in 1987, 1991 and 1999. High adjustments to numbers can be difficult to achieve in practice due to limitations on transport, market constraints and availability of livestock.

Total grazing pressure in—or adjacent to—wooded land types preferred by kangaroos may impact on the safe utilisation level and is difficult to account for in the long-term.

Inaccessible areas within paddocks, such as the top of steep-sided jump-ups, should be discounted as should areas distant (>3 km) from water. The current water distance discount factors are derived from studies in the NT and could be improved through further studies in Queensland.

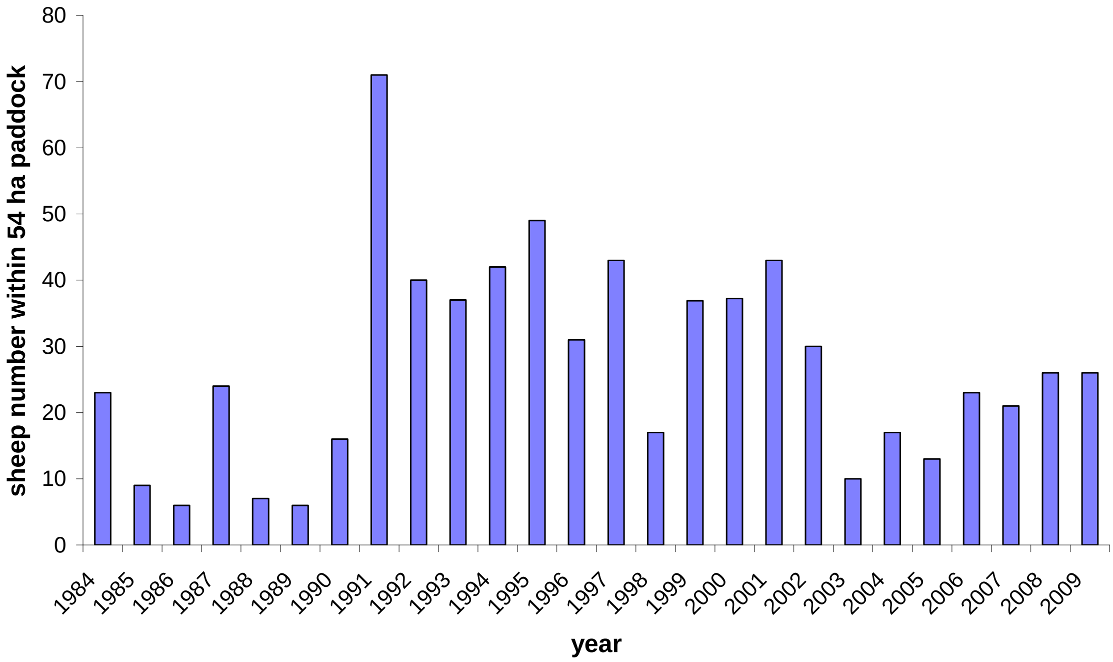


Figure 4. Annual variation in sheep numbers between 1984 and 2009 under a very low grazing pressure to consume 10% of standing feed at Toorak research station.

Local recommendations can vary according to the individual's property circumstances and these circumstances need to be defined and taken into consideration when settling on a new stocking rate or carrying capacity.

The carrying capacities derived using the safe carrying capacity calculators in GLM and Stocktake are a guide only but their relative differences due to changes in land condition or tree density are important when making decisions.

6.1.5. Management action: use forage budgeting to adjust stocking rate to seasonal conditions

There is strong interest from graziers in the Mitchell grasslands in adopting more flexible approaches to adjust stocking rates using forage budgeting. Forage budgeting can be used to take advantage of above-average season when there is more feed on offer, to plan stock number reductions in below-average seasons as feed declines and to plan for pasture spelling. Given these different purposes it is important to have goals in mind when preparing a forage budget. Forage budgeting is the most accurate way to adjust stock numbers around the benchmark long term carrying capacity.

Forage budgeting provides an accurate means to adjust stock numbers when used with skill and with knowledge of the technique and the land being managed. The skills involved generally build on those used—often intuitively—by experienced graziers to set stock numbers for a paddock. There are indications that it is important to reduce stock numbers quickly as pasture yields decline and re-build numbers slowly to allow pastures to recover as yield increases.

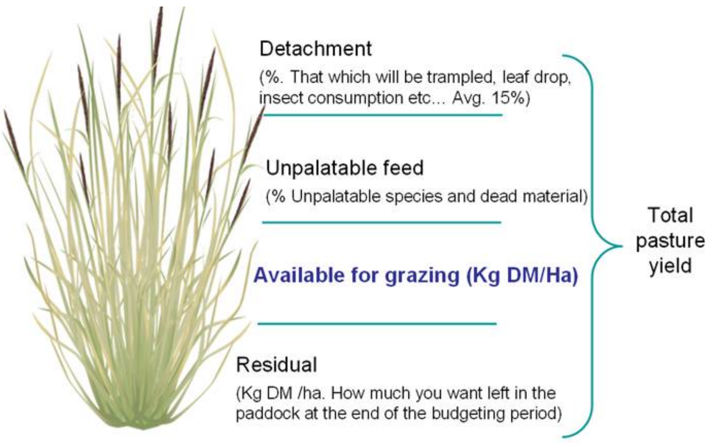
A forage budget should account for detachment and unpalatable feed. It should leave adequate residual to protect the soil from erosion or provide carry over feed ready for the next grazing cycle or in the event of drought.

This is shown pictorially on the right.

Note that a forage budget is calculated using pasture weight, not height. For Mitchell grass in good condition, a residual of 15-20 cm is 1000-1500 kg/ha (dry weight).

Graziers have expressed a desire to maximise liveweight gains by grazing over the summer growing season. This tactical approach has a high degree of risk. This risk may be tempered with appropriate managerial inputs to monitor and adjust livestock numbers according to pasture response.

Stocking rates may be increased above the long-term carrying capacity in good seasons to take advantage of above average pasture growth with lower risk of harming the pasture, but prompt action is required to reduce stocking rates as pasture availability and seasonal conditions decline. It is usually the combination of high stocking rates during periods of low rainfall and pasture availability that result in major declines in land condition that can persist for years and, perhaps, decades. It is wise to set an upper stocking rate limit even for very good seasons to avoid the risk of excessive pasture utilisation rates if subsequent conditions are poor. This upper limit may need to be specific to land types of the Mitchell grasslands and could be based on an upper limit of about 30% higher than the property long-term carrying capacity, depending on the extra pasture growth in better years. Increases in individual paddock may be higher for shorter grazing periods and still be safe. Changing stock numbers in this way may not actually change annual pasture utilisation rates in better years but keep the utilisation rate fairly constant.



The local recommendation from consultation with experienced graziers is to use feed budgeting along with available climate outlooks and tools e.g., to set dates for selling stock if no useful rain is received by that time. Useful climate tools include the SOI, Madden-Julian Oscillation (MJO), historical records (for analogue years), as well as some wildlife indicators like behaviour of emus and meat ants. Whilst more accurate forecasts/outlooks would be welcomed, graziers see the current tools are being helpful to inform stocking decisions. Some good insights to the reliability of ENSO as a rainfall and pasture growth predictive tool are given in Clewett and Clarkson (2007).

Experienced graziers suggest that April is a critical time to reduce stock numbers, especially in poor years of below average pasture growth where the decision to sell or commence targeted feeding is crucial. Stocking rates should be reduced quickly in poor years, especially during poor wet seasons because of the sensitivity of perennial grasses to grazing at this time. Plans for a progressive reduction in stocking rates during deteriorating seasonal conditions should be developed to avoid crisis management. Livestock classes should be considered when destocking, selling the least productive animals first. This may include splitting breeders based on age and feed demand. Having 'core' breeder and 'trading' dry animals in the herd provides the flexibility to adjust to changing seasonal conditions, although the optimal long-term mix of breeders to trading livestock is difficult to determine.

Having country in good condition provides opportunities to buy in. Experienced graziers suggest that when to buy in depends on the timing of rainfall, amount of feed, quality of the feed and how feed quality may change in the coming months. Increasing numbers in April/May has the advantage of knowing the amount of forage on offer, but includes the risk of a rapid loss of pasture quality due to spoiling rains or—to the south—frosts. Increasing numbers during winter is seen as a gamble as feed quality is already in decline. Buying in August/September may overcome these risks as the stage of decline of feed quality is generally evident by then. Cattle prices are generally low in August/September, providing an added market advantage. There is a risk of having too high a stocking rate going into the early wet season. This needs to be managed through feed budgeting.

The more information available on markets, feed quality and quantity (both at the time and over the following 6 months), the better it is for making decisions.

6.1.5.1. Evidence

A number of trials have been conducted over the past 30 years examining the effects of utilisation rate on pasture performance [Ecograze (spear grass), Toorak (Mitchell grass, Burenda (Mitchell grass), Arabella (mulga)]. While the method of determining utilisation rate varied between studies (consumption of a percentage of pasture grown during that year for Ecograze versus consumption of a proportion of the end of growing season yield over the following year for other studies), these trials showed declines in both animal production per head and pasture condition as utilisation rate increases.

Wambiana is the only trial to experimentally test using variable stocking rates where animal numbers were changed each year at the end of the growing season. The variable stocking regime gave good financial returns overall but had problems (both financial and declining land condition) in the transition from good to poor years.

Cattle grazing experiments at Longreach and Blackall commenced grazing in March, or at phase 3 pasture growth, without impacting on Mitchell grass even under high stocking rates (Phelps 2006).

Bio-economic modelling for the open downs land type suggests that perennial grasses can be retained—and hence land condition maintained—by using flexible (or variable) stocking rates ranging from 6.7 ha/AE to 14.4 ha/AE (Figure 5). This supports the interest in using flexible management approaches. The modelling also suggests that perennial grasses decline over time under too high a stocking rate—regardless of stocking rate strategy or spelling. This threshold is yet to be defined for the Mitchell grasslands but presumably it exceeds 6.7 ha/AE.

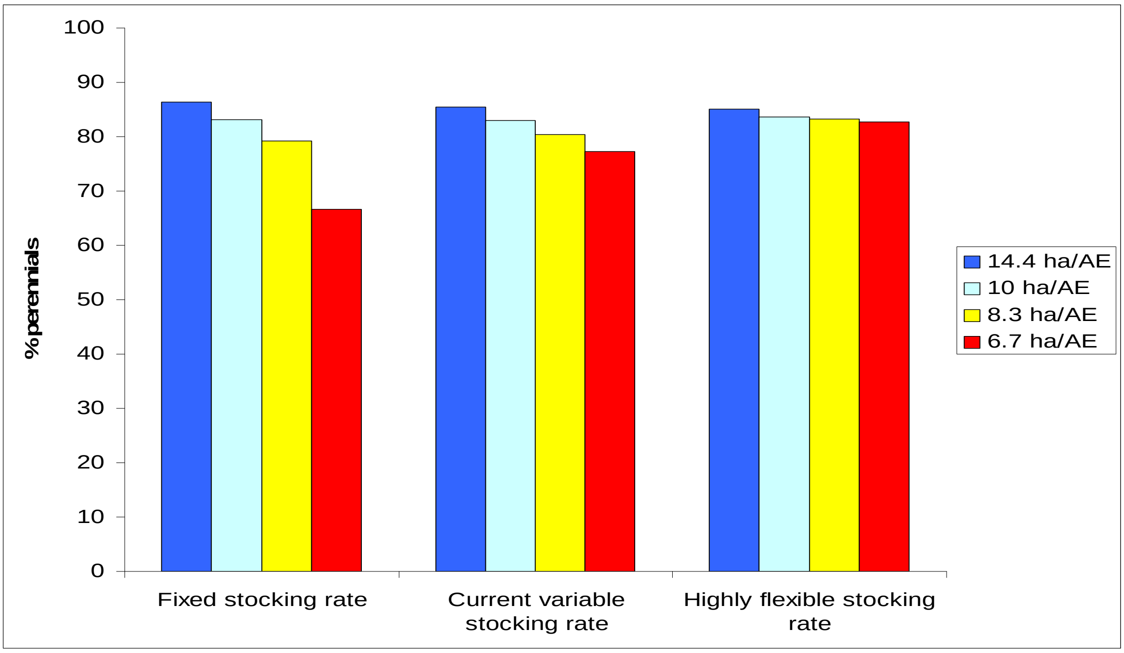


Figure 5. The estimated % of perennial grasses present in the long term under fixed, current or highly flexible approaches to stocking rates.

Bio-economic modelling also suggests that stocking rate strategies can become too flexible. The highly flexible stocking rate had greater economic risk than fixed (i.e. not adjusting stocking rates) or the (assumed) current level of variation on stock numbers. The highly flexible stocking rate approach returned a negative gross margin (GM) in 10 out of 30 years (Figure 6) but did return the highest GM in a single year (Table 6). The highly flexible option provided the same average GM as the fixed stocking strategy, but with much higher risk as shown by 10 years running at a loss and a substantial loss of $15.27/ha in the worst year.

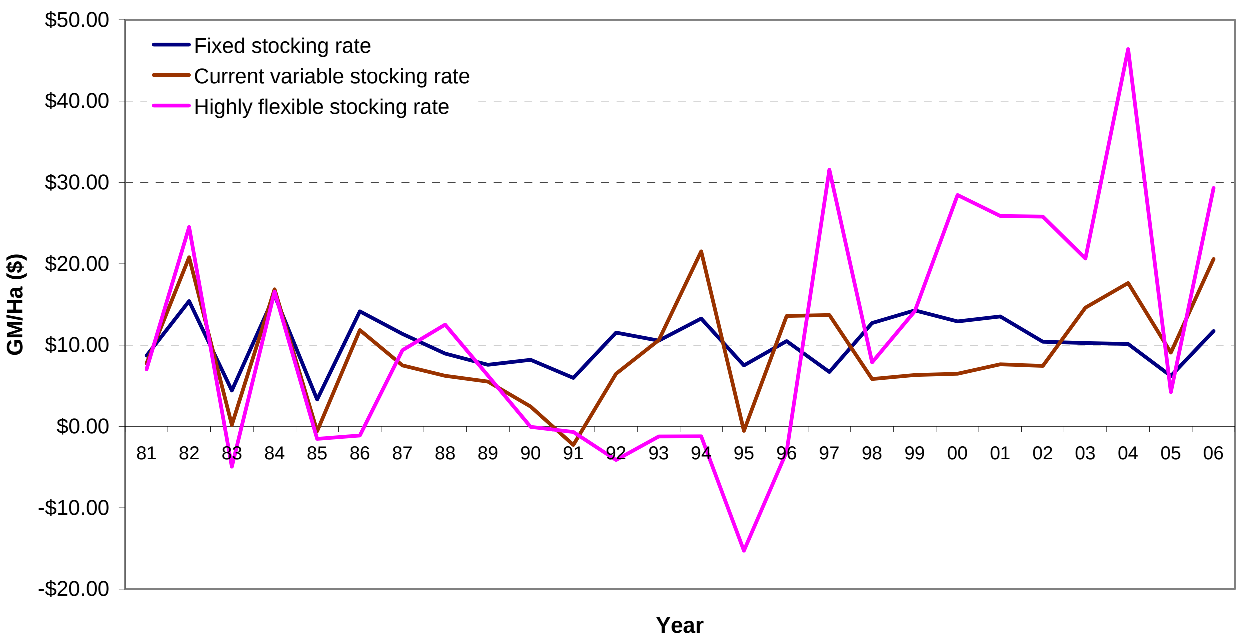


Figure 6. Gross margin ($/ha) analysis of fixed, current or highly flexible stocking rate approaches to stocking rate between 1981 and 2006.

Table 6. Key gross margin ($/ha) results from an analysis of fixed, current or highly flexible stocking rate approaches to stocking rate between 1981 and 2006.

	Stocking rate strategy		
	Fixed	Current variable	Highly flexible
Average GM	$10.25	$9.12	$10.66
Minimum GM	$3.32	-$2.27	-$15.27
Maximum GM	$16.11	$21.53	$46.39
Negative income years	0	3	10

6.1.5.2. Implementation

Forage budgeting can be used at the end of the wet season to set stock numbers for the coming 12 months or to set numbers for shorter grazing periods (often 90-120 days but up to 210 days). Annual adjustments are more common for breeders whilst shorter term adjustments are useful for younger or trade stock. Shorter grazing periods would generally be recommended to start no sooner than the mid to late wet season once the majority of the Mitchell grass in the paddock has gone to seed. Both approaches can also be used to lease country or negotiate agistment terms.

Graziers in some areas (e.g. Tambo) suggest it is better to commence shorter grazing periods towards the end of the dry season to reduce the risk of poor forage quality due to frost or spoiling rains. This approach starts from low forage quality and improves over the wet season but involves the risk of over-grazing Mitchell grass in its sensitive early growth phases (phase 1 and 2).

Successful forage budgeting in the Mitchell grasslands involves:

- Accurately estimating pasture yields using photo-guides (e.g. from Stocktake) or other means (e.g. cutting pasture samples).
- Setting end-of-grazing period residual pasture yield (generally 1000–1500 kg/ha) and Mitchell grass stubble height (generally >20 cm) targets appropriate to the management goal and seasonal conditions.
- Closely monitoring declining pasture yield as the grazing period and/or target residual yield is approached.
- Closely monitoring pasture response in the early wet season and be ready to reduce stock numbers if the response is poor compared to the rain received.
- Monitoring changes in pasture yield and Mitchell grass stubble height—especially when seasonal conditions change—to quickly reduce numbers should yield decline faster than anticipated or to gradually take advantage of improved pasture growth.
- Monitoring changes in forage quality (e.g. due to unseasonal winter rain, mist or frost that can quickly reduce forage quality; or as stem in the cattle diet increases towards the end of the forage budget period).
- Anticipating changes in pasture yield based on short to medium-term rainfall predictions—there may be opportunities to increase stock numbers further, to increase live-weight faster, or to aim for a larger residual yield.
- Allowing the majority of Mitchell grass in a paddock to start to set seed (i.e. within late phase 3 growth) before increasing stock numbers (usually by mid-March).

Cattle production can decline towards the end of shorter forage budget periods. This may be a sign that cattle have increased the intake of grass stem or other less-palatable pasture components. This is an indication that stock numbers are too high—even if the residual yield or stubble height have not been reached. From a production perspective it is useful to anticipate the need for supplementary feeding as pasture quality declines. From a pasture perspective it is a sign to provide some relief to the paddock through either spelling or reduced stock numbers. It is also a sign that future yield estimates should be more conservative.

Shorter grazing periods (generally 90, 120–150 or 180–210 days) with agisted or trade cattle are useful approaches to make use of feed surplus to the requirements of the core herd. Shorter grazing periods are also an essential element when planning wet season pasture rest periods. Shorter gazing periods may commence as early as mid-March but possibly much later depending on the seasonal and market conditions.

Feed budgeting approaches in the Mitchell grasslands need to include drought management strategies. Stocking rates should be reduced in poor years especially during failed wet seasons (because of the sensitivity of perennial grasses to grazing at this time). Plans for a progressive reduction in stocking rates during deteriorating seasonal conditions should be developed to avoid crisis management. Re-stocking should also be progressive—and slower than the de-stocking—to allow drought stressed pastures to recover.

Consider your drought strategy when setting a residual yield: 1200 kg/ha may be inadequate in the event of a failed summer. During a run of below average wet seasons, the starting yield may be lower than the recommended residual yield. In these seasons, graze cautiously with low stocking rates. Attempt to retain Mitchell grass stubble height in excess of 10 cm and be prepared to use pasture rest as a tool to aid Mitchell grass and general pasture recovery at the end of the drought.

Adjust stocking rates at least twice a year as necessary (at the start and end of the dry season). Where it is feasible, reduce stocking rates during the wet season if rains are poor to help protect pasture condition.

6.1.5.3. Considerations/caveats

High cattle density increases detachment rates considerably in Mitchell grasslands, risking over-estimates of potential stock numbers. It is known that detachment rates can be as high as 50% under high stock density but it is not clearly understood at what density this occurs. It seems that the detachment rate increases suddenly beyond an upper threshold of stock density.

There are economic penalties for trying to introduce too much change in animal numbers. The risk of land degradation is higher when grazing over summer, closer monitoring and more active management is needed to prevent this from happening.

Stocking rate decisions should be based on an assessment of current land condition. This should consider patterns of grazing distribution within paddocks. Where they have been developed, use plant and soil indicators to inform decisions about the need to reduce stocking rates to avoid land degradation as pasture availability and seasonal conditions decline. The condition of perennial grass tussocks (such as the amount of residual biomass or stubble height) are important indicators of future plant survival and pasture productivity. Reducing stocking rates late in the wet season may allow seed production by palatable perennial grasses. Maintaining minimum levels of ground cover is important to protecting the soil.

Good growing seasons with an ample supply of feed may be an opportunity to rest pastures to maintain condition and/or to use fire to manage woody plant populations (see Section 6.3). Mitchell grass plants grazed to less than 10 cm stubble height in the mid-dry season and then rested for the entire wet season, survived severe drought better than plants of greater stubble height. However, grazing below 10 cm stubble height during the growing season leads to high Mitchell grass mortality (up to 75% or plants and segments of plants).

It is worth bearing in mind that the length of a short-term feed budget can vary by about 4–8 weeks depending on seasonal conditions and how accurately the starting yield was estimated.

There is some evidence that Mitchell grass dieback during the 2002-2009 ‘Millennium’ drought may have been made worse by retaining very old and weathered stubble (>2 years old). Effective options for drought management are elusive but should be based on the same principles of good land management as in good seasons. It is difficult to maintain stubble or yield above the minimum targets during drought as the starting yield and height are often below the desired minimum for the end of the grazing period. Practical implementation under these circumstances may include reducing the targets, accepting potential land condition impacts and plan to accelerate drought recovery by retaining low stocking rates and implementing full wet season spelling.

During severe or extended drought events even country in good condition becomes unproductive and at risk of degradation. A to B condition country is often dominated by tussocks which lack vigour instead of the usual healthy and robust plants. Often there are just one or two stalks (tillers) growing from a mostly dead tussock. Mitchell grass plants can remain alive for an estimated 630 days under drought, but this extra stress makes them more vulnerable to grazing impacts. Under these circumstances management for recovery is probably similar for managing for C condition recovery (see next section).

The drought experienced from 2002 until the 2008/09 summer lead to the loss of Mitchell grass even under conservative grazing and in ungrazed areas due to its severity. The key factor was below average rainfall coupled with high evaporation—such as experienced in western Queensland over the 2002/03 summer. It is possible that these conditions dry out the soil for the full rooting depth of Mitchell grass (generally >1 m) and prevent access to deeper moisture that keeps the grass alive during drought dormancy (Phelps *et al*. 2007).

6.1.6. Management action: implement pasture resting

Resting pastures can both increase the amount of pasture grown and reduce the amount consumed. This can increase the total feed supply or defer when it is consumed. Pasture resting also has a role to play in maintaining and restoring pasture condition (see Section 6.2).

6.1.6.1. Evidence

While there has been considerable research on using pasture resting to improve land condition, there has been little study of the effects of pasture resting on land in good condition. One of the few studies was the Ecograze project at Charters Towers where resting paddocks in the early growing season each year for eight weeks combined with 50% utilisation gave similar pasture performance to 25% utilisation without pasture rest. Both these treatments maintained land in good condition.

Pasture resting during the early growing season avoids the grazing of regrowing perennial grasses when they are most sensitive to defoliation. By allowing patches to grow without continual re-grazing, they become more like the remainder of the pasture and animals are less likely to return to these patches.

A general conclusion from South African studies was that pastures in good condition should be rested one year in four (and more often for pastures in poor condition).

6.1.6.2. Implementation

Where the aim is to grow more feed then spelling pastures will need to be during the growing season and after sufficient rainfall to promote enough growth of pasture to transfer energy and nutrients back to the depleted root system but if the aim is to reduce consumption then this can be any time during the year.

From a practical perspective, the spell period to improve land condition should commence at the beginning of the growing season for long enough to allow the Mitchell grass to reach phase 3 (seed set). By this stage there should have been sufficient transfer of nutrients to the plant roots for recovery providing there has been enough rain, as discussed earlier. It is also important to allow 3P grasses to set seed in most years.

6.1.6.3. Considerations/caveats

Although the aim of spelling in this case is concerned with the amount of feed available for animals, it is logical to assume that spelling should give additional benefits in terms of maintaining or improving land condition. However, there is little evidence of these benefits for the Mitchell grasslands. Based on Bio-economic modelling, good land condition is maintained provided stocking rate is matched with long term carrying capacity in the medium to long term.

Results from grazing studies (Phelps 2006) indicate that spelling is needed to allow Mitchell grass to recover following high grazing pressure (Mitchell grass plants grazed to less than 10 cm stubble height). There may also be gains in deferring grazing until late phase 3 growth following shorter-term grazing periods where residual pasture yields have been reached.

Resting country for a full wet season following drought should allow for maximum recovery, although there is only anecdotal evidence to support this. The same recovery may be achieved by maintaining low stocking rates, and hence low utilisation rates.

Kangaroos and wallabies are a major problem in many parts of the Mitchell grasslands. Spelled pastures are often over-grazed by very high densities of roos and wallabies and land condition suffers as a consequence and landholders are invariably discouraged from spelling pastures. There are control techniques, some involving elaborate technology, or simply culling. Culling is often unsuccessful due to the high numbers of roos and wallabies involved and other options such as roo-proof fencing and high-tech options are expensive. The economics of fencing and high-tech options have not been rigorously tested to date, or little information exists, but there are some demonstrations in the region employing these techniques.

6.1.7. Management action: implement prescribed burning

Fire can be a useful tool to control the invasion of gidyea (see Section 6.3.4) and to reduce feathertop (*Aristida latifolia*) and hence improve land condition (Phelps 2006).

An effective management fire burning feathertop.

6.1.7.1. Evidence

Feathertop is an unpalatable wiregrass (*Aristida* spp.) with a high proportion of tough stems and is a poor quality feed (Phelps 2006). Patches of unpalatable feathertop in the pasture forces the animals to more heavily graze palatable pastures, in turn creating degraded patches where the palatable pasture was. Pastures dominated by feathertop have reduced overall grazing value as the palatable feed is suppressed; they can also be substantially lower yielding than the same land type in better condition. Animal productivity is consistently reported as low within wiregrass dominated pastures. Feathertop can suppress Mitchell grass yield by up to 70%—even when Mitchell grass density is still moderate (a spacing of 2–3 m between plants). The moderate density of Mitchell grass indicates B land condition—despite the low contribution to yield—as it still has the capacity to respond to rainfall.

6.1.7.2. Implementation

A single mid-dry season burn (June/July in most instances) when soils are dry and dry conditions are maintained for six to eight weeks following the burn will reduce feathertop and return country to productive A condition. Up to 75% of existing adult feathertop will be killed as will seed on the soil surface and the next season's potential seed crop. A minimum of 1,500-2,000 kg/ha of fuel is needed to produce a clean and effective management burn.

6.1.7.3. Considerations/caveats

Graziers within the Mitchell grasslands will generally not contemplate fire as a management option, even for feathertop control. There are no other control options, although severe drought reduces feathertop and cattle grazing can slow its increase. It is thus possible that the conversion from sheep to cattle grazing will lead to less feathertop.

Patchy burns—with remnant areas of intact feathertop left behind—allow for rapid re-seeding and the potential for populations to quickly re-establish. Feathertop is able to recover rapidly from a single burning event if 25 mm or more of rain is received within 6–8 weeks of burning. End of wet season burning can be detrimental to Mitchell grass given the length of time (up to 10 months) before rain is normally received.

A patchy burn leaves intact feathertop plants ready to recover with rain.

Burning includes a short-term opportunity cost through the reduction in available forage that could otherwise be grazed. The reduction in available forage also increases the exposure to drought risk, should the following summer receive well below average rains. Preparing a feed budget plan for the property can identify if the opportunity cost is real, and reduce the risk of running short of feed during drought. Only burning when the SOI, or other indicators of rainfall, shows a high probability of summer rain will also reduce this risk. Allowing feathertop to persist represents a long-term opportunity cost through foregone grazing potential.

Some areas burnt in the lead up to the 2002-2009 drought responded better to rainfall events during the drought and helped maintain land condition. The mechanisms involved are unclear but is probably because all the old tillers were replaced with fresh tillers better able to withstand drought.

6.2. Pasture in poor (C) condition

When land is generally in poor condition there is low density and vigour of 3P grasses, low ground cover, undesirable pasture species, frequent feed shortages and obvious overgrazed patches. Land condition needs to be restored to restore productivity and profitability. The essential management actions are reducing stocking rate to match the less productive carrying capacity, wet season spelling and using forage budgeting to adjust stocking rate to seasonal conditions.

The previous section (6.1) referred to situations where paddocks are in good to fair (A or B) condition overall. In this section we are dealing with the estimated 53% of Mitchell grasslands in generally poor (C) condition (Phelps *et al.* 2007) e.g. rapid assessment of land condition in 2006 estimated that about 50% of Mitchell grass land types were in C condition in the north-west and central-west statistical divisions (Figure 7).

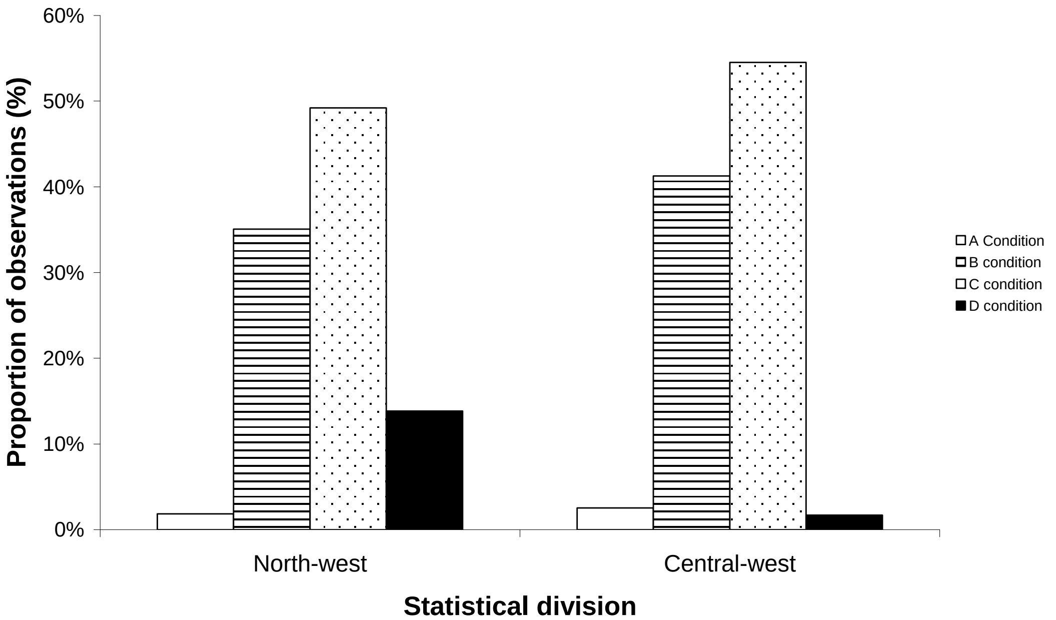


Figure 7. Proportion of A, B, C or D condition classes in 2006 within the north and central-western amalgamated shire divisions (Phelps *et al*. 2007).

Land in C condition has about half the gross margin (GM) of production as country in B condition and is generally unprofitable in the long term. If a property were to decline from B to C condition over a five year period, the enterprise becomes unprofitable with negative operating, net and economic profit[4] eroding the capital base (Table 7; Figure 8). A negative economic profit means the return on labour, land, and capital is lower than other forms of investment—in this case ten-year government bonds. The economic impact would become worse over the long term unless country is restored to B or A land condition. Potentially the longer that land remains in C condition the more difficult it is to recover to B (or A) condition as the amount of seed of 3P grasses and other desirable plant species in the soil declines over time. This has not been tested and could warrant further research.

[4] Where: GM is total farm income minus variable costs; operating profit is the difference between total farm income and farm operating costs (variable + fixed costs); net profit is operating profit minus depreciation, bank interest, family labour and tax; economic profit is operating profit minus the change in market value of farm capital, and the opportunity costs of farm labour, land and capital; balance sheet includes assets, liabilities, and owners equity.

Table 7. Detailed whole gross margin (GM, $), profit, cash flow and balance sheet analysis for a representative northern Australian cattle property with Mitchell grass pastures, with land condition declining from B to C in year 2 (Phelps *et al*. 2007)

Year	**0**	**1**	**2**	**3**	**4**	**5**
Land Condition (class)	B	B	C	C	C	C
Carrying capacity (AE)	3231	3231	3232	1711	1711	1711
Closing no.	3231	3232	1711	1711	1711	1711
Activity gross margin ($)	$434,043	$388,353	$1,419,003	$166,387	$157,503	$148,905
Profit ($)						
Operating profit	$253,840	$196,985	$1,053,587	$2,494	-$7,259	-$15,943
Net profit	$100,032	$63,151	$665,570	-$96,447	-$102,525	-$105,685
Change in trading stock	$363	-$213,017	-$1,107,059	-$60,077	-$41,249	-$39,530
Economic profit	-$94,560	-$316,825	-$488,798	-$282,570	-$256,113	-$242,485
Cash Flow ($)						
net change in cash	$133,271	$94,807	$695,719	-$67,734	-$75,180	-$79,642
Balance sheet ($)						
Total assets	$4,371,327	$4,191,379	$3,784,872	$3,579,907	$3,380,993	$3,173,526
Total liabilities	$472,229	$472,229	$472,229	$472,229	$472,229	$472,229
Owners equity	$3,899,098	$3,719,150	$3,312,643	$3,107,678	$2,908,764	$2,701,297

In this example, there is an initial income spike when cattle are forcibly sold due to declining pasture yields and the inability to carry high numbers for any longer. A similar situation occurs at the on-set of drought. The risk of sliding into C condition is also greater during drought—especially severe drought—than at any other time.

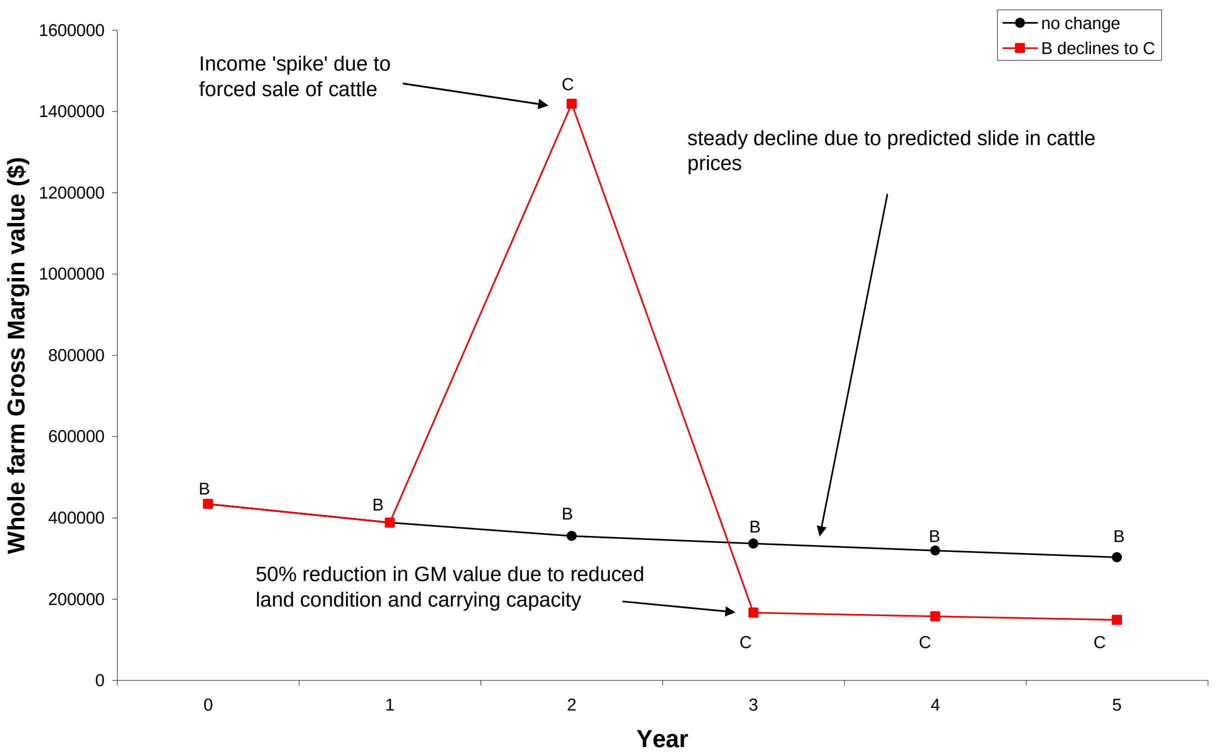


Figure 8. Whole farm gross margin (GM, $) analysis for a representative northern Australian cattle property with Mitchell grass pastures, with land condition held constant at B compared with to C in year 2. Annotations indicate key GM changes (Phelps *et al*. 2007).

6.2.1. Signs

Most of the paddock or particular parts of the paddock (e.g. preferred land type) are in C condition.

For the Open Downs land type this is demonstrated by a tussock spacing of 20–30 m, a substantially reduced capacity of land to respond to rain and produce useful forage (<40%), highly variable ground cover levels over time and 3P grass contribution to yield generally <60%.

The 3P grasses have thinned considerably and the pasture is dominated by desirable annual grasses or forbs or by un-desirable plants. Feed shortages may develop quickly in dry periods although ephemeral high nutritional quality feed may be available for short periods.

The most serious limitation to improving land condition is a reduced density of 3P grasses. The soil seed bank should still be present to enable species composition recovery.

The aim of management is to increase the basal area and seed production of individual Mitchell grass plants and to take advantage of seedling germination to restore 3P grass density.

6.2.2. Causes

Severe drought—such as that experienced from 2002 to 2008/09—can lead to the loss of Mitchell grass and a decline to C land condition. This can occur under conservative grazing pressure or even in the absence of grazing. The key factor during drought appears to be below average rainfall coupled with high evaporation such as experienced in western Queensland over the 2002/03 summer. It is possible that these conditions dry out the soil for the full rooting depth of Mitchell grass (generally >1 m) and prevent access to deeper moisture that keeps the grass alive during drought dormancy (Phelps *et al*. 2007). Observations in 2002–2008/09 suggest there are potential management practices to reduce Mitchell grass plant mortality during severe drought but actual management strategies are not yet clear.

Mitchell grassland condition can also deteriorate in the absence of grazing or burning. Presumably the pasture composition of these open grasslands was maintained through regular wildfires prior to pastoralism—possibly as large mosaic patches. Grazing has become the surrogate defoliation mechanism with the exclusions of fire and seems to maintain Mitchell grass plant vigour and health under moderate grazing pressure (Orr and Phelps 2004).

Long-term overgrazing is the major cause of C condition country outside of severe drought conditions—often a result of misjudged carrying capacity. Frequent and severe defoliation can have deleterious effects on both individual plants by reducing their vigour and on soils and pastures by reducing land condition (lower cover and more bare ground, lower infiltration and more run-off, altered botanical composition, patchiness). Drought can further damage weakened pasture, as can intense wildfire.

The 3P grasses are often selectively grazed within the pasture leading to them being weakened, resulting in their death or reduction in size and vigour. Seed production of 3P grasses may be prevented and recruitment of new 3P grass seedlings is minimal.

With the demise of 3P grasses other plants increase which have strategies to survive the grazing pressure. This may be quick growing and prolific seeding species (e.g. button grass) or species with unpalatable traits (e.g. wiregrasses, rattlepods) resulting in avoidance by livestock. Unpalatable traits may include tough leaf blades and stems, chemical deterrents or physical deterrents (prickles and spines).

Bio-economic modelling suggests there is a threshold high stocking rate which leads to a large drop in perennial grass percentage in the pasture and hence a decline in land condition over time. This threshold has yet to be defined for the Mitchell grasslands. It is clear that pasture spelling is unlikely to prevent this decline without reduction in overall stocking rate as well.

6.2.3. Management response: reduce carrying capacity to match land condition, implement wet season spelling and use forage budgeting

The keys to recovering C condition land are to encourage the small number of Mitchell grass plants—and other 3P grasses—to expand in size at the base, to set seed and to promote regeneration through seedling establishment. To achieve this it is necessary to adjust stocking rate to match a realistic long term carrying capacity, introduce pasture spelling, manage animal numbers to minimise periods of feed shortage and wait for the favourable conditions needed for Mitchell grass the germinate and establish.

6.2.4. Management action: reduce long term carrying capacity to match land condition

Some areas—particularly Ashy Downs—appear to have an unrealistically high expectation of long term carrying capacity. Stocking rates reported by graziers in northern Ashy Downs country suggest estimated stocking rates up to 6–7 ha/AE as the long term carrying capacity. Under a fixed stocking rate strategy (Section 6.1.5.1) this would lead to a steady decline in perennial grasses. Mitchell grass plants are poorly anchored in the loose clay soils of the Ashy Downs land type—making them susceptible to being pulled out during grazing—and suggesting that the long-term carrying capacity of the Ashy Downs is lower than Open Downs.

Observation suggests that cattle numbers exceed the safe long term carrying capacity in areas of the north and north-western Mitchell grasslands. This has created large areas of C condition country dominated by annual grasses—such as Flinders grass. Whilst Flinders grass is palatable, pastures dominated by annuals suffer feed shortages almost every year by August/September. Continued over-grazing in this situation exacerbates the problem by pushing high grazing pressure onto remnant Mitchell grass plants.

6.2.4.1. Evidence

Long term pasture growth is reduced to about half the potential under C land condition. Attempting to maintain the same carrying capacity as expected for A condition will result in chronic long term overgrazing and exacerbate the decline in 3P grasses. Even when coupled with pasture spelling (e.g. one year in every four) lower stocking rates than A condition are required to increase perennial grasses. Land in A condition retains a high proportion of perennial grasses even at higher stocking rates (e.g. 6.7 ha/AE, Figure 5) and under a range of stocking strategies. In contrast, land in C condition only begins to improve under a low stocking rate of 14.4 ha/AE—even when combined with spelling (Figure 9).

6.2.4.2. Implementation

There is generally adequate Mitchell grass seed in the soil to promote effective recovery following above average summer rains when coupled with effective grazing management. Long term carrying capacity should be re-calculated for C condition country using the GLM workshop approach and coupled with a wet season spelling plan to restore land to B condition. Plans should account for rainfall variability by also introducing forage budgeting to avoid grazing Mitchell grass below the minimum residual stubble height of 15-20 cm or residual yields of 1200–1500 kg/ha.

6.2.4.3. Considerations/caveats

Property size, debt levels and cash flow issues may be strong impediments to graziers implementing lower stock numbers. Mitchell grass has only been observed to germinate and establish in substantial numbers once every 20–30 years as the favourable combination of above average summer rainfall and low competition from annual plants are infrequent.

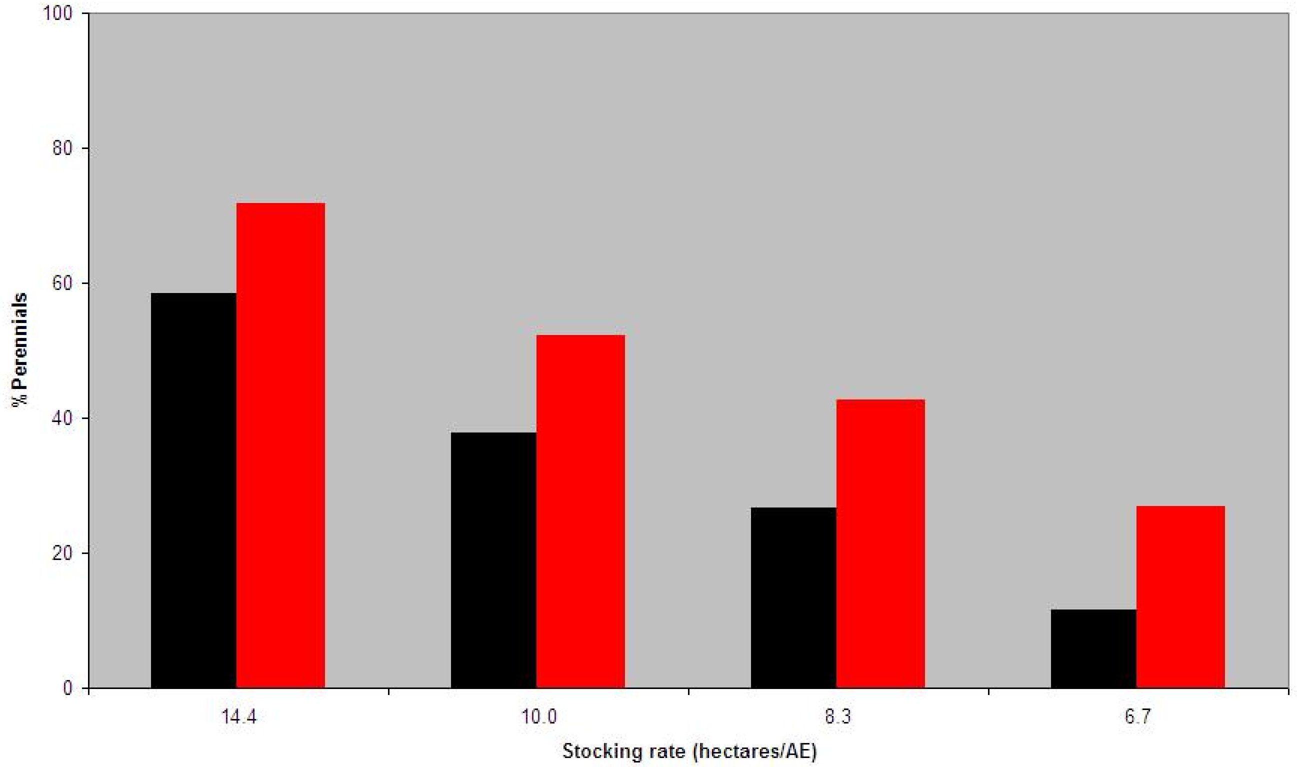


Figure 9. The impact of wet season spelling one year in four (red bars) compared with no spelling (black bars) under four stocking rates on C condition Open Downs country.

6.2.5. Management action: implement pasture resting

A more realistic long term carrying capacity will be most effective when couped with full wet season

spelling to improve land condition. Installing additional infrastructure may be useful to move stock away from preferentially overgrazed land types or to enable the application of pasture resting.

The likely ephemeral pasture species present although less desirable than 3P grass may still produce useful forage often for short time periods before setting copious amounts of seed. This useful forage can be nutritious for short periods, although there will probably not be a large bulk. To effectively utilise this forage without causing further land degradation requires flexible grazing strategies which match stocking period and stocking rates to this forage cycle (see Section 6.2.6). Care must be taken to prevent further overgrazing and resource degradation which is likely if the pasture is continuously stocked.

Frequent and severe defoliation reduces the vigour of individual plants and impacts on soils and pastures by reducing land condition (lower cover and more bare ground, lower infiltration and more run-off, altered botanical composition, patchiness). Rest aimed to benefit pasture condition targets both the health and reproduction of individual plants and the overall land condition.

6.2.5.1. Evidence

Bio-economic modelling suggests that a four paddock rotation can recover three out of four paddocks in poor condition, provided stocking rates match the safe utilisation level (Figure 10). Where stocking rate exceeds the safe utilisation level it is likely that only one or two paddocks can be restored to good condition.

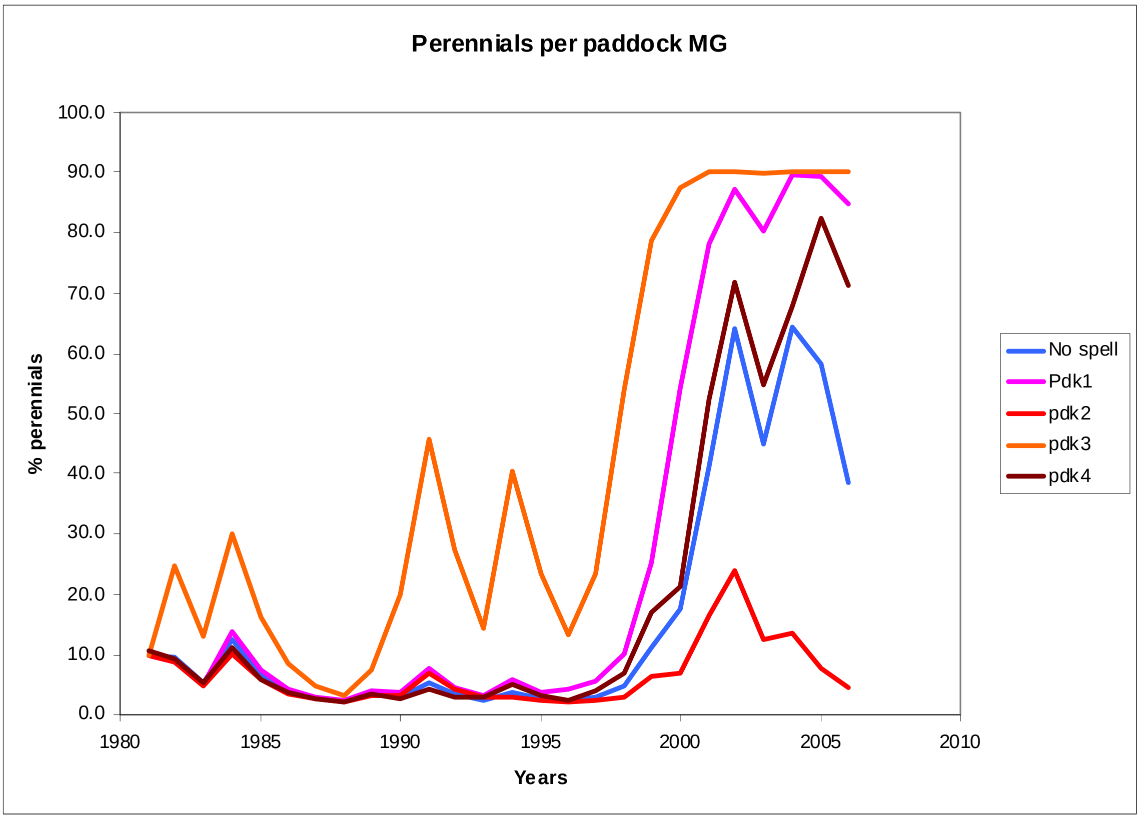


Figure 10. Change in perennial grass percentage (from Bio-economic modelling) a) within the pasture of individual paddocks under a one year out of four spelling system (pdk1–4) and b) on average within all four paddocks with no spelling. The paddock spelling in the forth year (pdk2) did not recover.

6.2.5.2. Implementation

A feed budget approach should be coupled with estimates of long-term carrying capacity.

Minimal gains will be made with resting if following the rest period stocking rates are not matched to feed supply and ongoing overgrazing occurs.

A general recommendation for improving pasture condition is to have a planned but flexible regime to rest paddocks for the whole growing season commencing from the first rain event sufficient to initiate new growth (38–50 mm in three days). Resting regimes can be described by their timing (seasonal), duration and frequency or number of rest periods.

Substantial evidence exists across many regions that indicate spelling during the wet season and particularly during the early growing season when grasses are most susceptible to heavy defoliation is important for encouraging 3P grasses. Rest during the dry season may also be useful for maintaining ground cover and improving rainfall infiltration for the following growing season.

At the individual 3P grass scale, the grass needs time to initiate a leaf canopy to commence photosynthesis, and then to grow, re-build root reserves and produce seed (Figure 11). Seedlings require time to grow a strong root system to survive the follow dry season.

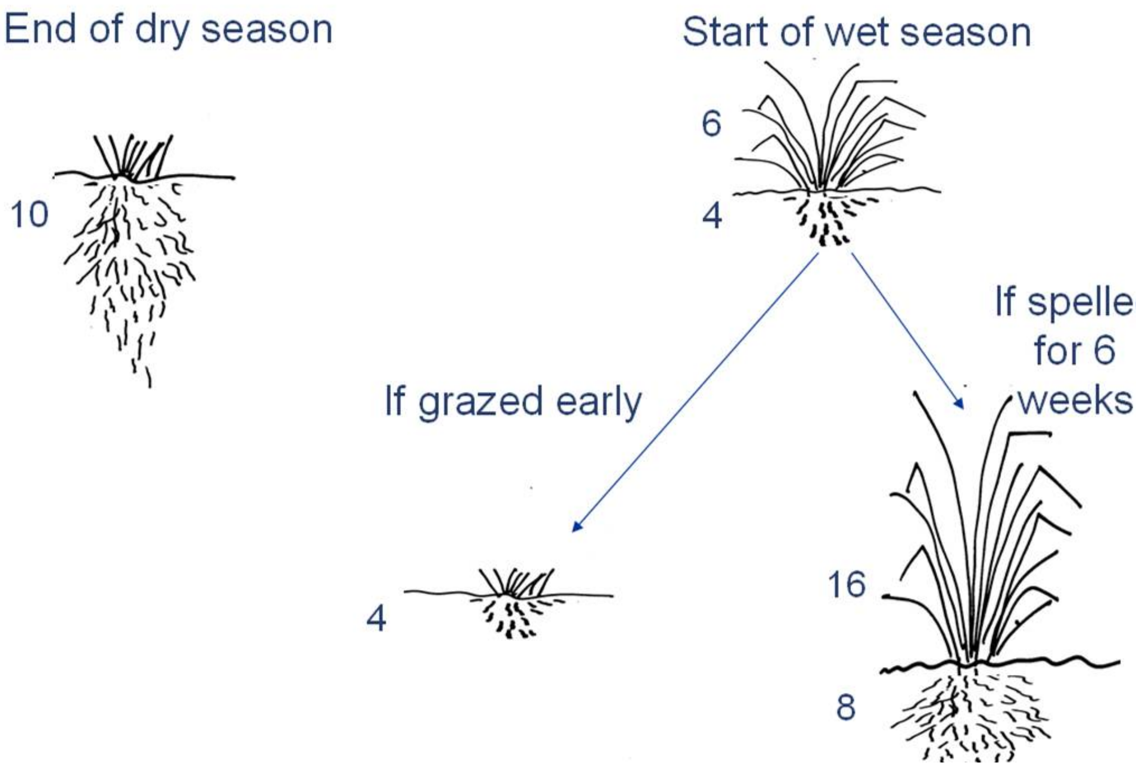


Figure 11. The energy left in a 3P grass at the end of the dry season (e.g. 10 units) is redistributed differently according to early wet season grazing or spelling, affecting how well the grass will grow over the rest of the wet season.

The required frequency of resting or number of rest periods to achieve a certain goal will be determined by both initial land condition (resting alone is unlikely to be sufficient to restore D condition land) and growing conditions experienced during the rest period (pasture maintenance and recovery are boosted by good seasonal conditions). Establishment of seedlings from the seed set during an earlier rest period may be enhanced by a subsequent rest period.

Increasing the number of rest periods can be expected to give a greater pasture response but represents a trade-off as grazing is foregone during the rest period. There are no experiments in northern Australia dealing explicitly with comparisons of the frequency of rest periods but a number of trials provide useful information indicating that as land condition declines pasture rests need to be more frequent if land condition is to be improved.

The duration of rest period for poor condition pastures should be a minimum of eight weeks, however resting for the whole growing (wet) season has been shown to be desirable particularly in below-average rainfall years.

6.2.5.3. Considerations/caveats

There have been no formal studies of the length of spelling or frequency of spelling needed to recover Mitchell grass low to moderate density and hence to improve land condition. Studies at Redland Park, between Kynuna and McKinlay demonstrated that rest over one summer of exceptional growing conditions can recover country from poor to good condition. In this circumstance spelling was for the full wet season. It is likely that full wet season spelling is needed for 2-3 summers if rainfall is about average and possibly 3-5 years if rainfall is below average.

Timing of rainfall is also important. Late winter and early summer rains can promote broad leaved plants to grow, such as roly poly and tar vine. These do not seem to out-compete Mitchell grass seedlings. With follow up rains, Mitchell grass seedlings should be able to establish if protected from grazing. However, annual grasses—such as Flinders grass—do out-compete Mitchell grass seedlings. It is possible that C condition areas dominated by annual grasses will have few opportunities for recovery and that spelling needs to be opportunistic.

It is likely that a property with less than half the paddocks in C condition and the rest in A or B condition is easier to recover than a property with more than half in C condition. Extra livestock can be moved onto the good condition country allowing more C condition paddocks to be spelled—provided the good condition paddocks are managed through feed budgets and are closely monitored.

The longer that country remains in poor condition, the longer it may take to recover. The amount of Mitchell grass seed in the soil was observed to decline during the 2002-2009 drought. The few isolated Mitchell grass tussocks present in poor condition areas would first need to recover and produce sufficient seed for a new generation of plants to establish. Research to date suggests that 6 plants/ha can produce enough seed for this to occur under good seed producing conditions.

Animal performance is likely to be good for a short period each year in C condition paddocks and poor for the majority of the year.

Fencing to subdivide paddocks may allow more flexibility for resting pastures, such as through rotational grazing systems. There is no literature that is conclusive in determining that rotational grazing systems are any better at improving land condition than continuous stocking of paddocks interspersed with periods of rest.

Breeding herds are difficult to manage when calving in rapid rotational grazing systems. If a mob is moved every few days or each week during the calving season, young calves are at risk of being separated from their mothers.

For breeding properties, aim to have at least three to four paddocks to shift breeders through over a year including the growing season. Determine the long-term carrying capacity according to land condition and tree basal area and sell excess stock. Run the breeders in three of the four paddocks in the early part of the growing season, until about mid January or the first round of branding. At first branding, redistribute cows to another three of the paddocks, spelling a second paddock in the later part of the growing season and grazing the paddock that was spelled during the early part of the growing season. At the second branding and weaning in June, redistribute cattle to all paddocks or rotate the cattle in one mob through all four paddocks. A forage budget at this time of the year will determine whether there is sufficient pasture to carry cattle through to the next growing season. If not, cull dry breeders, cull for age and other criteria to reduce numbers.

Repeat this system in the second year, spelling the two paddocks that weren't spelled in the first year. In the third year spell the two paddocks that were spelled in the first year but in a different order so that each is now being spelled at a different part of the growing season than when spelled in the first year.

For dry stock and growing cattle, aim to have four to six paddocks so stock can be rotated through paddocks regularly, using short term rapid rotational forage budgets. This will allow paddocks to be grazed for periods of two to eight weeks (two months) at a time giving each paddock a spell for some time in every growing season. Use forage budgets at the end of the growing season to determine whether there is enough pasture to last stock until the onset of the next growing season.

6.2.6. Management action: use forage budgeting to adjust stocking rate to seasonal conditions

Forage budgeting is an important component of restoring land in C condition to productivity. Forage budgeting for C condition land should aim to introduce a full wet season spell as well as ensuring remnant Mitchell grass plants are grazed no lower than 20 cm stubble height by the end of the grazed (budget) period. To maximise the benefits of a full wet season spell grazing should not re-commence until the majority of the remnant Mitchell grass plants in the pasture have set seed, or not before early March. The forage budget will need to account for a usual rapid decline in pasture yield by the end of September due to weathering and windy conditions.

The same principles and strategies apply as for land in good condition (Section 6.1.5) but it is likely that the country is most suited to short grazing periods (e.g. 90-210 days) rather than annual budgets. C condition Mitchell grass country may thus be best suited to backgrounding operations and are unlikely to be suited to breeding operations—especially if trying to restore land condition. If large areas of a property are in C condition it may be appropriate to have a low number of (or no) breeders and concentrate on restoring land condition with cattle classes or enterprises (e.g. short term agistment) that offer the most flexibility in de-stocking. De-stocking would be necessary in most instances by August/September.

6.3. Woody plant problem

Woody thickening and encroachment is typified by large numbers of seedlings or saplings establishing into what used to be open or lightly wooded areas. This is often a result of sequences of very wet years, reduced competition from grasses due to heavy grazing, reduced intensity or frequency of fire, and possibly by rising carbon dioxide levels. The essential management actions are using prescribed burning to kill or suppress woody plants, matching stocking rate to a reduced long term carrying capacity and spelling to promote post-fire pasture recovery.

An estimated 20–30% of the Mitchell grasslands of western Queensland are wooded land types. Gidyea invasion into open downs land types and thickening in wooded land types are the most common issues with native tree and shrub species. Thickened gidyea is generally in C or D condition with the loss of 3P grasses and evidence of soil loss and erosion. Boree has thickened in some areas—most notably around Isisford—and is invading open land types in limited cases. Other tree and shrub species, e.g. mulga, are thickening within their land types but rarely invading into open country. The most prevalent woody weed problem is invasion by prickly acacia—especially in the northern Mitchell grasslands around Hughenden, Richmond and Julia Creek. Mesquite is an issue in some areas and Parkinsonia is widespread along major drainage lines of riparian land types (e.g. Open Alluvia).

Thickening and invasion by gidyea and boree appears to be accelerating, possibly as sheep are being replaced by cattle. Sheep are observed to graze small (2-leaf stage) gidyea seedlings when they emerge following rains and boree seedlings within browse height—potentially providing a control mechanism. Cattle do not graze such small seedlings. Anecdotal evidence from fence-line contrasts of low and high gidyea density with and without sheep grazing support their potential role in controlling gidyea thickening and invasion. It further suggests that gidyea will become a greater problem over time as sheep grazing is replaced by cattle.

Gidyea thickening and invasion—or other trees and shrubs in isolated cases—will:

- Compete with more palatable or more nutritious forage—reducing pasture yield—and reduce long term carrying capacity.
- Limit the access of livestock to water in dense stands.
- Create difficulties for mustering (both sighting and accessing animals) in dense stands.
- Harbour pest animals such as feral pigs.
- Provide habitat for kangaroos and wallabies, increasing the total grazing pressure and hence the risk of land degradation.
- Generally reduce biodiversity values.

In the open Mitchell grasslands, however, patches of trees—such as vinetree, whitewood, supplejack and corkwood—are desirable to:

- Provide shade and shelter to livestock.
- Provide browse as a supplement to cattle diets.

There is a balance in trying to encourage the re-establishment of desirable trees on stony ridges and patches in the open land types and reducing the invasion and thickening of gidyea.

6.3.1. Signs

Seedling gidyea or boree spreading into open land types and forming dense thickets in wooded land types—especially within and adjacent to Wooded Alluvia and Soft and Hard Gidyea.

The size, number and distribution of woody plants can all be useful indicators of the impact that woody plants are having on the pasture. In general a low density of large scattered trees and shrubs is likely to have little deleterious effect on a pastoral production system and may, in fact, be beneficial. People’s memories of previous vegetation states (lower tree and shrub densities, for example) can be unreliable. Importantly, the change in woody plant biomass may be gradual and imperceptible so photographic records—including aerial photographs and satellite imagery—provide more useful and reliable information for comparison over time. Another important sign of current or impending problems can come from an examination of tree and shrub population structures. A large proportion of small plants (seedlings, saplings) may indicate a growing population though caution is necessary when making such interpretations.

6.3.2. Causes

Many factors drive tree and shrub populations. Some of the important ones are indicated in Figure 12 which portrays the dynamic balance between tree, shrub and pasture (mainly grasses) components of the vegetation. The main drivers of the dynamic are rainfall as a promoter of germination and growth, drought as a cause of mortality, competition between grasses and woody species (for water, light and/or nutrients), grazing and browsing differentially affecting biomass and possibly survival, and fire as a remover of herbaceous biomass and a cause of top-kill and mortality of woody species. Some of these factors can be managed; some cannot. Among the factors driving observed or quantified increases in populations of woody plants are: sequences of very wet years, reduced competition from grasses due to heavy grazing, reduced frequency and/or intensity of fire because of lack of fuel or active fire suppression or, as suggested in some literature, rising CO_2 levels. The significance of these factors is likely to vary from place to place. One important relationship is that between plant size and susceptibility to fire. For many species, small plants are more susceptible to fire than large plants. This means that increasing 'woodiness' associated with a lack of fire can create a positive feedback in which an effective fire becomes less likely. This feedback loop is exacerbated by the negative effect of increasing woodiness on fuel loads.

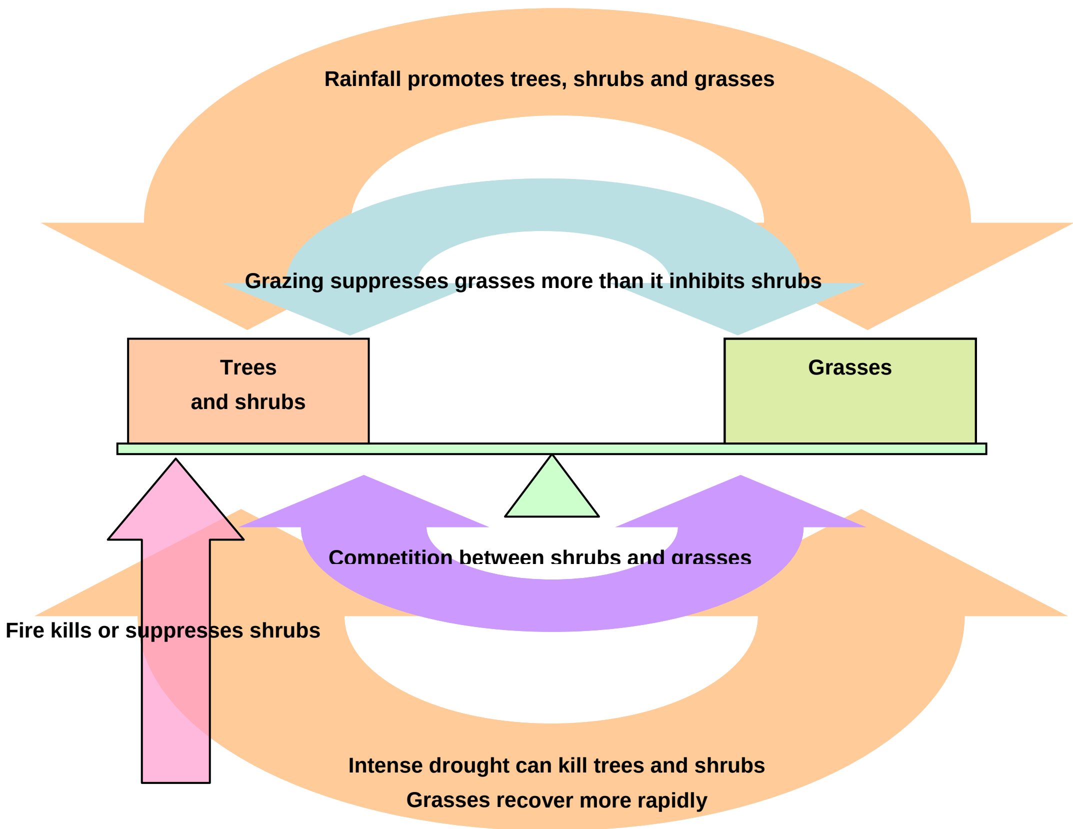


Figure 12. Factors affecting tree and shrub populations.

6.3.3. Management response: fire and grazing

Fire and grazing/browsing are the principal manageable factors that influence the woody components of northern Australian vegetation. Critically, these two manageable factors interact with one another (Figure 12) as herbivores and fire, in effect, compete for herbaceous material. Prescribed burning, then, constitutes a management response to increasing woodiness of northern Australian vegetation.

6.3.4. Management action: use prescribed fire to kill or suppress woody plants

Prescribed burning is one of the options to control tree and shrub species. The action would involve instituting a regime of mid-late dry season burning: the most useful regime depending on the woody species present; their density; and the size class structure of their populations. More intense fires may be useful for species that are more tolerant of fire, where tree and shrub densities are high and where plants are large. Less intense fires may be suitable for fire-susceptible species or where the purpose is to reduce or suppress a cohort of recently-established (i.e. small) shrubs.

6.3.4.1. Evidence

A lot of the fire research that has been conducted in northern Australia has focused on the ecology and management of the woody plant strata of the vegetation. This work has included research on native communities in the Top End and Victoria River District of the Northern Territory and the Northern Gulf savannas and Cape York Peninsula woodlands in Queensland as well as on invasive woody species in the Burdekin woodlands of north-east Queensland. Research is lacking for many regions and vegetation communities.

CSIRO research demonstrated that prickly acacia seedlings shorter than 1.5m can be killed by fire.

6.3.4.2. Implementation

Implementation of a regime of prescribed burning to manage woody plant populations requires planning. The emphasis should be on a fire regime rather than on individual fires. Fires should be timed to suit the purpose for which they are intended rather than following a simple schedule. This will generally mean waiting for those years in which fuel loads are adequate.

Gidyea is reputedly killed easily with a fire when it is shorter than 1.5–2 m in height. Once mature, a hot fire which will reach up into the canopy appears necessary. There is limited research into controlling gidyea with fire.

To achieve a hot fire, a minimum of about 2000 kg/ha of standing dry matter is needed. The lower the stocking rate, more productive the land type and lower the regrowth the more frequently a hot fire can be carried. Open downs country can carry a hot fire 4 years in 10 (on average based on the last 100 years of rainfall) if not grazed for that period and just 1 year in 10 under higher stocking rates (Figure 13). Soft mulga sandridge does not grow enough fuel—even when ungrazed—to carry a hot fire (information not presented). Despite conventional wisdom, bio-economic modelling strongly suggests that there is little extra benefit in spelling to achieve a fire—possibly because it is difficult to predict when spelling is needed in relation to above-average summer rainfall.

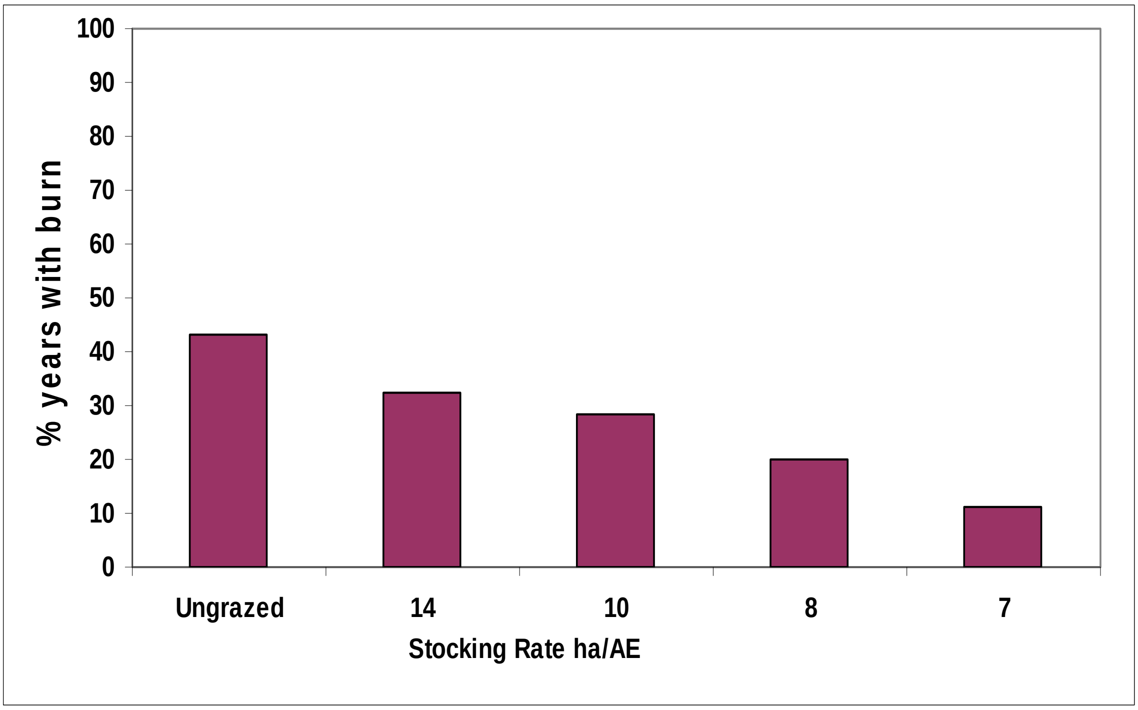


Figure 13. Lower stocking rates create more opportunities for fire in Open Downs.

6.3.4.3. Considerations/caveats

Graziers within the Mitchell grasslands will generally not contemplate fire as a management option, even for woody plant control. A major reason for this is the immediate loss of forage which could be grazed in the short term or needed as drought reserve within the next 12–18 months. Mechanical or chemical options may be more readily adopted.

There are some important considerations when contemplating the use of fire to manage woody plant populations. The first is that prescribed burning comes at a cost. Costs will be associated with any resting of pastures that is required in order to build up fuel loads so that an effective fire can be achieved. The costs associated with burning to control thickening or encroachment are generally immediate whilst the benefits may not be seen for decades.

Burning when fuel loads are inadequate to achieve the purpose of the fire is obviously counter-productive. Likewise, it is important that pastures are not grazed too soon after the fire. Grazing in the immediate post-fire period would hinder the recovery of desirable pasture species. In particular, it is ideal that palatable, perennial grasses are allowed to set seed in the post-fire period and this may require destocking or, at least, very low stocking densities. If pre- or post-fire destocking is necessary, forage must be available for livestock on other parts of the property or off-property or they would have to be sold.

Prickly acacia can provide useful browse—which may contribute significantly to livestock diets—and shade, contributing to livestock performance. As a result there is reluctance from some graziers to treat this weed.

6.4. Ungrazed areas distant from water

Paddocks within the western portion of the Mitchell grasslands or where non-downs land types dominate are generally the only remaining areas with considerable areas rarely grazed by livestock due to long distances from water points. In these areas, this unused pasture represents livestock production that is forgone by the pastoral business, whilst areas near water often become degraded through overgrazing. Paddocks in other areas of downs have sub-optimal water placement along fence-lines or in corners of paddocks. Management options that create the opportunity for cattle to use this pasture have the potential to increase returns to the livestock enterprise by allowing more cattle to be carried where paddocks are currently stocked below the carrying capacity. Improvements in individual livestock production however are unlikely. The essential management actions are to install more water points in large paddocks and optimise paddock size. Fire may sometimes have a role (to remove accumulations of old forage and improve grazing distribution) and spelling may aid the recovery of previously overgrazed areas.

6.4.1. Signs

In large paddocks, significant areas of the paddock distant from water points that contain palatable forage receive little or no grazing and accumulate masses of ungrazed herbage. The areas near the water points that are subject to very high utilisation are also likely to be large and/or expanding quickly.

6.4.2. Causes

The problem of having ungrazed areas distant from water principally arises in large paddocks with few water points where animals are unable to reach the distant parts of the paddock during daily foraging activities. Cattle need to drink regularly (usually once a day) under the hot conditions experienced in northern Australia. Since there is a limit to how far they can walk between drinks they can only travel a limited distance from water to forage, leaving areas of pasture beyond the usual foraging distance from water. In addition to having insufficient water points, poorly located water points (in relation to factors that influence grazing distribution such as topography, shade or favoured areas) can also contribute to this problem.

If stocking rates for a paddock are based on paddock size but there are too few water points for the size of the paddock, there will be an excessive number of cattle per water point. This will contribute to the development of large, expanding areas of overgrazing and land degradation around water points.

6.4.3. Management response: develop water point and paddock infrastructure

The most important management response involves making the areas of palatable forage accessible to cattle (i.e. all areas are within walking distance of water for the cattle) by establishing more water points. Improving the control of cattle grazing distribution by reducing paddock size is also an important response. This helps minimise the extent to which large numbers of cattle congregate in favoured areas of pasture or use favoured water points. If developing new water points and reducing paddock size makes the areas of ungrazed pasture available to cattle it may be possible to increase the number of stock carried (providing the long-term carrying capacity of a paddock is not exceeded). If a paddock is usually stocked at the safe carrying capacity of the land, installing additional water points will not allow more stock to be carried in the paddock, but may help to distribute grazing pressure more evenly within the paddock.

6.4.4. Management action: install more water points in large paddocks

Establishing additional watering points in or near areas of unused palatable forage will increase the extent to which cattle graze those areas. It is the most important management action to implement. For the more extensive regions the distance from water to palatable forage should not generally exceed 3 km. Thus, to ensure reasonable levels of use of an entire large paddock water points should not be separated by more than about 5–6 km. A good rule of thumb is to allow one water point per 2000–2500 ha (20–25 km^2) of land area for extensive areas.

Graziers within the Mitchell grasslands suggest that waters should be placed 3–4 km apart (i.e. 1.5–2 km distance to water) to make even use of pasture within these open land types. Many bore drains and old earth tanks have been replaced with poly pipe and tanks since the early 1990s. Where this is continuing attention should be paid to current recommendations.

6.4.4.1. Evidence

To some extent, the notion that establishing more water points in ungrazed areas will increase use of those areas is self-evident. Practical experience bears this out. However, understanding the optimum number and distribution of water points to make best use of available forage and the associated response of livestock, productivity and land condition for a region can be informed by research. Most research on these issues has occurred in the more extensive regions (e.g. central Australia and the Top End). There is limited evidence from formal research studies for other regions. However, research in rangelands in the USA has also demonstrated that establishing new water points in under-utilised areas can increase grazing in those areas and reduce pressure on previously frequently used areas.

Although a number of studies have reported the maximum distance cattle will walk from water to forage in northern Australia (e.g. up to 11 km on the Barkly Tableland and usually no further than 5–8 km from water in central Australia), most grazing by cattle occurs much closer to water. Grazing pressure usually declines markedly beyond about 3 km from water, although where water points are sparse cattle will use areas further from water. For example, on the Barkly Tableland (where waters were separated by as much as 10 km or more) an assessment over a number of properties showed that 55–60% of cattle activity occurred within 3 km of water. Although some cattle activity occurred further from water this was low, particularly at the extreme distances. It is this uneven grazing that contributes to the problem of forage not being used effectively at distant sites.

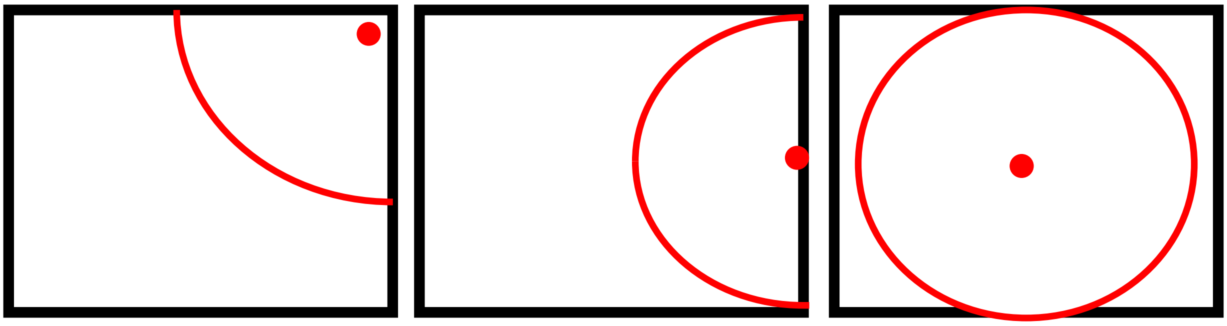
In the Pigeon Hole project—where additional waters were established in a large paddock—approximately 90% of cattle activity (assessed using GPS cattle collars) occurred within 3 km of water. This was because a large proportion of the paddock was within 3 km of water and there were smaller areas beyond this distance (the average distance to water in this paddock was 2.1 km). As a result there were fewer areas where ungrazed forage accumulated. Establishing new water points in large paddocks at Pigeon Hole allowed more cattle to be carried because more of the country was accessible for grazing. Thus a general recommendation to improve the effective use of available pasture and minimise the size of areas of ungrazed pasture in the more extensive grazing regions is for the majority of a paddock to be within 3 km of water and the distance between water points not to exceed 5–6 km.

One study of cattle grazing distribution in a commercial-sized paddock (1500 ha) north-east Queensland (using GPS collars) showed that the majority of cattle activity occurred within approximately 2.5 km of water and the average distance cattle were from water was approximately 1500 m from water (see McIvor *et al*. 2010).

6.4.4.2. Implementation

Waters should be sited away from fence lines and areas that cattle favour (e.g. creek lines, riparian areas, shady sites) whenever possible as this may help in reducing the extent to which cattle congregate around the water for lengthy periods and reduce the possibility these areas will be overgrazed. They should also be sited away from sensitive parts of the landscape, such as away from highly erodible soils or steeper areas where erosion can become an issue from erosion and stock tracking which can divert water. Studies in semi-arid rangelands in SA and WA have shown that grazing use within paddocks is more evenly distributed if water points are located away from fences. Although corner and paddock boundary locations for waters are preferred from a cost perspective, they create problems because they concentrate cattle in a smaller area and increase the effective stocking rate close to water (**Error! Reference source not found.**). This creates larger sacrifice areas around the water and can negatively impact on production because animals need to walk further to access feed. A centrally located water point dramatically increases the watered area of the paddock and results in lower effective stocking rates within 5 km of water (Table 8).

Table 8. Example of the impact of water point placement on effective grazing area and stocking rate.



	Corner Water	Fenceline Water	Central Water
Total paddock area (km²)	100	100	100
Number of head in paddock	300	300	300
Area within 5km of water (km²)	20	39	79
Stocking rate within 5km of water (head per km²)	15	8	4

In many areas of the Mitchell grasslands additional waters have encouraged increases in kangaroo and wallaby numbers and can attract pigs or other feral animals. Dams should be fenced off to control feral animals and consideration given to kangaroo control e.g. kangaroo proof fencing on dams and turning troughs off when not in use. One novel approach being tested is to place connections at regular intervals along new pipelines to allow a cup and saucer tank to be moved and reconnected as a deterrent to kangaroo grazing, to distribute cattle grazing pressure and to reduce capital cost.

6.4.4.3. Considerations/caveats

There will be regional differences in how many water points are needed and how far apart they should be placed. These differences will be influenced by the productivity and heterogeneity of the land and by other management considerations. In the more developed regions water points are usually already closer than the recommendations.

The cost of developing new water points must be considered. Where installing new water points 'opens up' new country to grazing the investment is more likely to be worthwhile. The quality of the land in ungrazed areas should also be considered prior to installing additional water points. Some land may be ungrazed because of low value pastures rather than because it is too far from water, and installing a new water point to make this area more readily accessible to cattle may not be financially worthwhile.

In a paddock that has multiple water points cattle will not necessarily distribute themselves evenly amongst the different waters. In very large paddocks carrying many animals this can result in large congregations of cattle on certain water points. The number of animals using a water point should be limited to approximately 300 head (McIvor *et al*. 2010). Graziers recommend two troughs per watering point.

It is also important to note that despite having improved access to water, cattle will continue to graze paddocks unevenly. Other techniques to attract cattle to under-utilised areas should also be implemented. For example, the strategic location and regular relocation of supplements, 'crash-grazing' over one or two dry seasons to 'even-up' paddock pasture use, slashing around troughs to encourage new cattle pad formation and strategically burning patch grazed areas or areas with an accumulation of old senescent pasture may help.

If fire is used to remove accumulations of old feed careful management is required after burning. It is generally considered important that perennial grasses in burnt areas be allowed to re-establish so there is a reasonable body of feed before they are grazed again after burning. Burnt areas are best rested from grazing for an entire growing season before being grazed again. Burning in the early dry season will effectively mean the paddock cannot be used for the remainder of the dry season since the cattle will concentrate on these areas and potential kill the regrowing perennial grasses.

Spelling may also be required to allow the recovery of overgrazed areas once new water points are established (see Section 6.2).

The effect of installing additional waters on the natural biodiversity of an area should also be considered. Many species of native fauna and flora now only exist in areas that are remote from water due to the impact of grazing on habitat or increased predator numbers due to increased water availability. Installing additional waters so that few water-remote areas remain may pose a risk to the persistence of this biodiversity. Where important biodiversity resources exist, some areas should remain remote from water (or fenced to exclude grazing) to protect these resources. A general suggestion is that up to 10% of a property should be set aside to protect biodiversity.

GLM workshops have typically recommended water points be placed 2–3 km apart in the Mitchell grasslands based on marginal gains in carrying capacity. This evidence has been based on earlier NT research and may require adjusting (see Chilcott *et al*. 2002).

Climate change predicts higher temperatures. This is likely to increase livestock water intake and may alter grazing patterns or increase the time spent at water points.

6.4.5. Management action: optimise paddock size

Subdividing large paddocks to create smaller paddocks will provide better control over where cattle graze and can thus improve the use of previously ungrazed areas and help reduce overgrazing of favoured areas. This is a much more effective way of managing and improving grazing distribution than simply adding more water points to a paddock. However the financial cost involved can be substantial and it might be a less attractive option than establishing additional water points.

6.4.5.1. Evidence

Although installing more water points to make ungrazed areas in a paddock more readily accessible to cattle can increase the use of these areas, large paddocks will not be grazed evenly because cattle prefer other areas. Some water points may also be preferred so a large proportion of the herd may graze in areas near those water points. Reducing the size of large paddocks provides better control over where cattle graze and improves the effective use of available forage, potentially allowing an increase in the number of stock carried with reduced risk of land degradation due to large concentrations of livestock occurring in favoured areas.

There is limited evidence from formal research on the effect of paddock size on grazing distribution and pasture use. The Pigeon Hole project in the VRD (Northern

Territory) is the only project to have specifically investigated the effect of different paddock sizes. Using GPS collars to record cattle distribution in paddocks over periods of six months, the research at Pigeon Hole indicated that individual cattle (and the mob as a whole) generally use a greater proportion of a paddock if paddock size is reduced. Confining cattle to smaller paddocks appears to have some effect in 'forcing' them to use areas they may not use if paddocks were larger (although they still may not use areas that contain few palatable plants). This effect means that having more smaller paddocks results in grazing being distributed more widely across the landscape as a whole, and should improve the effective use of available forage. It is also obvious that fences control where cattle can go at the landscape scale, thus preventing too many animals congregating on preferred parts of the landscape.

Reducing paddock size to that which approximates the usual grazing radius of cattle (i.e. the distance from water that encompasses the majority of cattle grazing) could be considered the ideal for many of the more extensive regions as it will mean most areas in a paddock are accessible to cattle. Assuming a grazing radius of 3 km this would translate to a paddock size of about 3600 ha (36 km^2). In paddocks of this size at Pigeon Hole the herd generally used 80% or more of the paddock area compared to approximately 70% in larger paddocks where additional watering points had been established. The research showed that reducing paddock size did not substantially improve the uniformity of grazing at smaller scales (e.g. patch scales) within paddocks. This suggests there is little value in reducing paddock size below that where all parts are accessible to cattle (i.e. 3000–4000 ha, 30–40 km^2) in the more extensive regions of northern Australia, from the perspective of improving grazing distribution. There are unlikely to be increases in total livestock production as a result of further reductions in paddock size.

There are regional differences in what is a suitable paddock size to aim for. A study of grazing patterns in smaller paddocks (500–2000 ha) typical of the Burdekin region of north-eastern Queensland found that the level of pasture defoliation varied little up to 2 km from water (McIvor *et al*. 2010). The small paddock size is likely to have contributed to evening out grazing use, although other environmental factors such as the degree of spatial variability in land type would also have been important. This evidence suggests that paddocks of 1500–2000 ha (15–20 km^2) might be appropriate for the Burdekin region (although there are no readily available data on grazing patterns for larger paddocks in this region). Graziers also suggest 1500–2000 ha is an optimal paddock size within the Mitchell grasslands as it allows a greater degree of control over grazing patterns, evenness of pasture use and simplifies the implementation of spelling as there are more paddocks to spread livestock through. Where sheep properties are being converted to cattle production it is recommend that the paddock sizes be retained—in some cases paddock are being enlarged to 4000–6000 ha—thus reducing managerial control over grazing.

6.4.5.2. Implementation

To better manage grazing impacts paddocks should be designed to separate minor land types that are sensitive to grazing (e.g. riparian zones, frontage country) where possible. Paddocks that contain relatively uniform land types and pasture are likely to be grazed more uniformly. In many situations this will not be practical due to relatively small size or irregular shapes of such areas. However, an understanding of how cattle use the landscape (e.g. their tendency to avoid steep or rugged country) should be used to inform paddock design.

Creating smaller paddocks will often also require the establishment of additional water points to provide water in all paddocks. Where possible it is recommended that the smaller paddocks contain at least two water points (particularly if they are around 3000–4000 ha, 30–40 km^2) since this would further increase the extent of the area grazed in paddocks, reduce the potential for excessive overgrazing around water points (by reducing the number of cattle per water point), and provide some safety and flexibility should one water point fail. Allowing at least one water point per 2000–2500 ha, 20–25 km^2 of land area is recommended to ensure all areas are accessible to cattle.

6.4.5.3. Considerations/caveats

Cost is a major consideration when reducing paddock size. Fencing costs escalate rapidly for paddocks smaller than about 3000 ha (30 km^2), and paddocks smaller than this may be hard to justify solely on the grounds of improving grazing management. The development of new paddocks should occur first on the most productive land where increased returns from development are most likely or to protect the most sensitive areas. Fencing may occur in stages as older fences need replacing.

For more productive areas with higher carrying capacities, smaller paddock sizes are likely to be warranted in order to better manage stocking rates, have mobs of a manageable size and minimise the occurrence of high concentrations of livestock within paddocks. Smaller paddocks facilitate the use of other management options and in some circumstances may reduce operating costs. For example having a greater number of smaller paddocks will increase the opportunities for pasture spelling, can make mustering easier and can facilitate the use of prescribed fire.

Smaller paddocks do not result in completely even use within a paddock. Some areas may still not receive much use and some areas will be heavily used. However, the rate at which overgrazed areas grow will be slower. As well as reducing paddock size, the use other of tools such as the strategic placement of supplements or prescribed fire should also be considered to improve grazing distribution in paddocks (see section 6.4.4.3).

7. Conclusion

Any of the best-bet practices for managing grazing lands in the Mitchell grasslands described in this guide ultimately have two desired outcomes:

1. Optimising animal productivity; and
2. Keeping the land healthy and productive.

No matter which grazing strategy is used on a property as long as management has planned to:

- Stock to carrying capacity for that land type and region.
- Factored in spelling to allow for pasture recovery, seed set and land condition maintenance or improvement.
- Are using strategies to even up grazing (strategic placement of waters, fences and supplements).
- Manage the encroachment of weeds, in particularly woody weeds,

they will be helping to improve land condition and productivity.

8. Contributing to best-bet practices in the Mitchell grasslands

This guide and other regional versions are the product of the Northern Grazing Systems (NGS) initiative which has been developed and implemented as a partnership between Meat and Livestock Australia (MLA), CSIRO, Agri-Science Queensland (part of DEEDI), the Northern Territory Department of Resources, and the Western Australian Department of Agricultural and Food.

Not all the regional guides were developed concurrently however to access other regional guides please contact David Phelps DEEDI Longreach, email: david.phelps@deedi.qld.gov.au phone: (07) 4650 1200 or Meat and Livestock Australia.

Research and development is ongoing. We are continually improving our knowledge and skills when it comes to Research, Development and Extension (RD&E) for the grazing lands of northern Australia.

You (the reader) in your work are also either contributing to or coming into contact with RD&E regularly and as such we would like you to contribute to improving this technical guide by providing your feedback to David Phelps DEEDI Longreach. Any contributions to this document will be welcomed and regular revisions of this document will help inform the work we and others do with grazing industries into the future.

Key findings from research projects right through to anecdotal evidence from reputable landholders will be gladly considered in future revisions. Information should address the four main issues or additional issues if you think necessary and then address one of the following headings:

- Signs (how the issue is expressed)
- Underlying causes
- Responses – the key practices and their rationale
- The specific management actions that can contribute to achieving better practice and the evidence base for these
- How to implement these actions
- The trade-offs, caveats, uncertainties and other associated issues.

9. Glossary of terms

Adult equivalent (AE)
A system that allows cattle of different age, weight and metabolic state to be compared equally according to their relative intakes. One AE is defined as a 450 kg dry beast maintaining live weight. One AE is equivalent to 9 dse.

Dry sheep equivalent
A system that allows sheep of different age, weight and metabolic state to be compared equally according to their relative intakes. One dse is defined as a 50 kg dry sheep maintaining body weight. One dse is equivalent to 0.11 AE.

Growing season
Most grass growing rain falls from November through to March in the Mitchell grasslands. During this period, energy from day-length, temperatures and radiation drive photosynthesis for pasture growth and seeding when there is adequate soil moisture.

Land condition
The capacity of land to respond to rain and produce useful forage. It is assessed by considering current pasture, soil and woodland condition. It is generally slow to change depending on long-term management and conditions.

Land type
Land types are manageable units of land, readily recognised by landholders as having distinct soil, vegetation, landform and productive capacity.

Long term carrying capacity
The number of stock which your paddock can carry, on average, year in, year out (>10 years) based on the type of country you have, it's current condition and the inherent climatic conditions. It is a useful benchmarking tool but actual stocking rates will vary below and above this value depending on seasonal conditions.

Pasture growth model
A computer program that estimates pasture growth by simulating ecological processes with mathematical relationships. In northern Australia, a model called GRASP gives the most accurate estimates of pasture growth.

Stocking rate
The number of stock as AEs per unit area at a particular time—usually expressed as ha per AE or dse.

Tree basal area
A measure of the competitive effects of trees on pasture growth, measured by the area of ground covered by tree trunks when they are measured 30 cm above ground level. This is negligible within open Mitchell grass land types, but can be extremely high within gidyea and boree land types.

Utilisation level
The amount of a pasture eaten by grazing animals usually expressed as a percentage of the total pasture grown in one season.

Wet season spelling
Resting pastures from grazing during the growing season. It is also referred to as wet season rest and summer-rest grazing.

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