Department of **Employment, Economic Development and Innovation**

Best-bet practices for managing the grazing lands of the Fitzroy Woodlands

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

MEAT & LIVESTOCK AUSTRALIA

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1. Introduction

This Technical Guide is designed to help inform and improve grazing management in the Fitzroy woodlands. It focuses on four major themes: managing stocking rate, resting 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 (part of DEEDI), 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.

Each region covered by the project will produce a Technical Guide, such as this one, as a way of capturing the best available technical information on key grazing practices. This information has been derived from various sources including a review of research reports, biological and economic modelling of different management options, and the input of producers and technical specialists from each region.

Production of this guide marks the end of the first phase of the NGS initiative for this region. The next phase of the initiative will focus on working 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.

2. How the guide was developed

This Technical Guide was developed by combining information from three major sources:

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). This review focused on four themes: managing stocking rate, pasture rest, burning and intensifying property infrastructure with more fences and waters.
2. Outputs from testing different management options via computer models. Effects of stocking rate, pasture rest and fire on pasture and animal productivity were simulated with the GRASP model. Grazing trial data and pasture growth studies have been used to develop GRASP, which can be run for specific land types and over any sequence of years. The pasture and animal productivity from GRASP was then used in an economics spreadsheet model called ENTERPRISE to assess how stocking rate, pasture rest and fire affect the economics of a beef enterprise with a herd and paddock structure typical of the region. This testing of options with GRASP and ENTERPRISE provides a way of extrapolating responses to grazing management measured in a grazing trial to a wider range of land types and climate conditions. It also provides a way to test lots of variations in grazing management that would be expensive and time-consuming to test on the ground. This helps identify the practices that have most impact and to narrow down the most cost-effective ways of implementing these practices.
3. 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 done over two workshops and via direct input to reports including this Guide. This local input also helped develop plans for the next phase of the 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, and variation of these 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 comprehensive so that it captures, in a readable fashion, 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 in several ways:
For people working with producers, as:

1. A means of improving their understanding of key grazing management practices and their awareness of the evidence base that underpins these practices.
2. A source of ideas for management strategies that will most cost-effectively address a particular issue or objective.
3. A guide to which issues/practices, and variations of these, deserve additional extension activity via demonstration sites or other processes.
4. 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 EDGE*network* 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 management across northern Australia

This document outlines best-bet management guidelines for common grazing management issues experienced in the Fitzroy woodlands of central Queensland. It draws on information from recognised literature sources, locally documented demonstrations and regional grazier experiences. The general guidelines that are applicable in the grazing lands of northern Australia are tabulated below and expanded upon in discussions at the regional level for each of the management issues.

Table 1. Guidelines for managing issues in the grazing lands of the 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 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 20 km^2 with two water points are sufficient from the perspective of optimising 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 not clear.

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.

The relationships between issues and management factors are shown in Table 2 and serve as the structure for this chapter.

Table 2. Management factors that can be used to address issues in northern grazing lands.

Issue	Management factor			
	Infrastructure	Stocking rate	Pasture spell	Fire
1. Matching of pasture supply/animal demand		***	*	*
2. Poor pasture condition	(*)	***	***	*
3. Woody plant problems		*	*	***
4. Ungrazed areas distant from water	***			

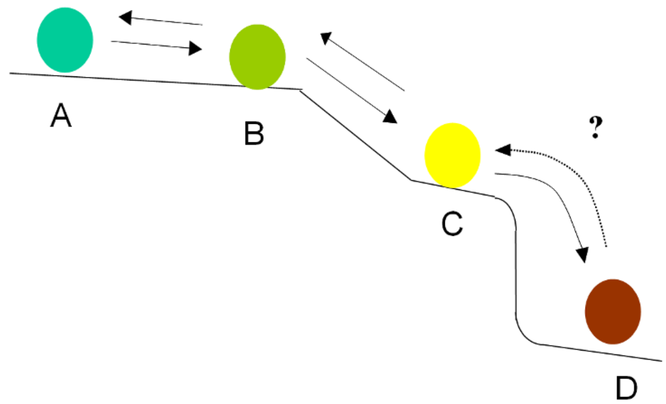
***** - strong effect, ** - medium effect, * - some effect, (*) – an interaction but not necessarily an effect.**

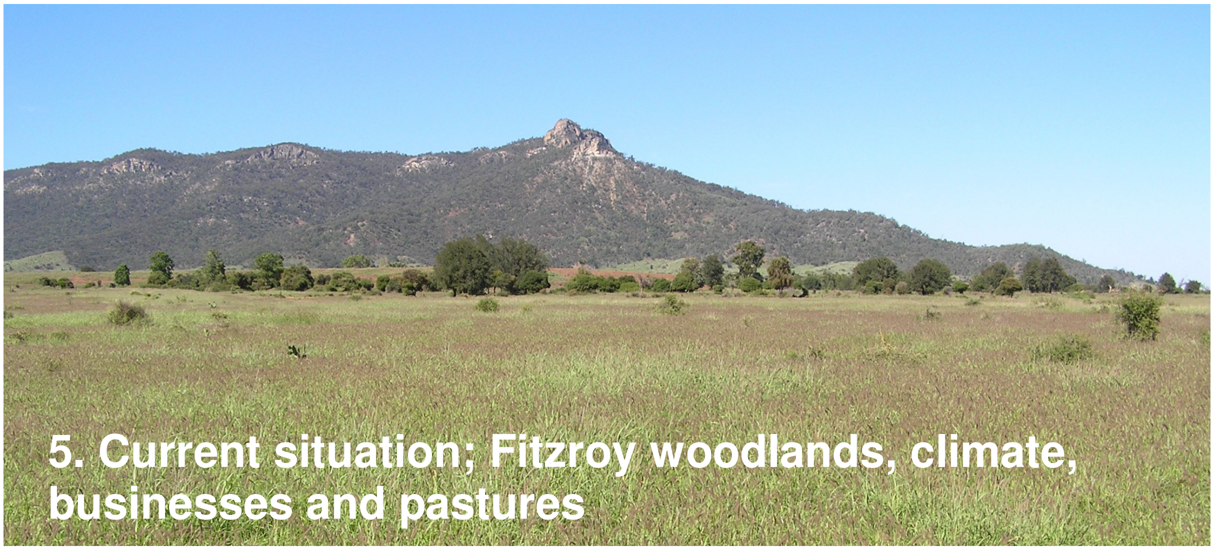
The guidelines and information in this technical guide are related to the management of three major issues that are common in the grazing lands of the Fitzroy woodlands and a fourth that is not so common, but a major issue in more extensive areas of northern Australia:
1. Matching pasture supply to animal demand on land in generally good condition.
2. Pasture in poor (C) condition.
3. Woody plant problems.
4. Ungrazed areas distant from water.
The relationships between issues and management factors are shown in table 2 and serve as the structure for this chapter. All these factors, described above, relate to managing for better land condition (Table 3). An explanation of grazing land condition and the ABCD framework follows. Land condition is the capacity of grazing lands to respond to rainfall and produce useful forage; it is about productivity and sustainability. 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 in 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 m2/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 EDGEnetwork GLM and the Stocktake pasture monitoring workshop packages





5. Current situation; Fitzroy woodlands, climate, businesses and pastures

Land types and climate

The Fitzroy woodlands are dominated by desert bluegrass and black speargrass on undulating hills to ranges. Major vegetation types are ironbark and box. The black speargrass dominated pastures are mainly in the east of the region. Other predominant land types include the Queensland bluegrass downs and brigalow scrubs. The ironbark, box and Downs land types are predominantly native pastures. Brigalow scrubs have mostly been cleared and have buffel grass established. The recognised land types within the Fitzroy woodlands can be viewed on-line at the FutureBeef website or ordered on CD-ROM from http://www.dpi.qld.gov.au/27_13350.htm.

The Fitzroy woodlands are in a sub-tropical environment with high rainfall variability, humid on the coast and semi-arid inland. The Tropic of Capricorn runs through the middle of the region. Mean annual rainfall ranges from 550–1300 mm with most grass growing rain falling from November through to March.

Land condition

About two thirds of the Fitzroy is in good condition (A or B), and less than a third in fair (C), with some areas in poor (D) condition (Beutel 2009 and Karfs 2009). Land condition is defined as 'the capacity of land to respond to rain and produce useful forage.' It relates to the potential to grow useful feed and is a good surrogate measure of ecosystem function.

The major land condition issues are on the ironbark, box and brigalow scrubs with duplex soils (Table 3). These soils are fragile and subject to scalding with a subsequent loss of 3P (palatable, perennial, productive) grasses. The Queensland bluegrass downs have been subject to a loss of bluegrass (3P) and spread of unpalatable wiregrass and weeds.

Table 3. Land condition characteristics

A CONDITION (GOOD)

- Pasture dominated with preferred plants
- Good 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 (more than 70% at the end of the dry season)

B CONDITION (FAIR)

- Pasture with a mix of non-preferred 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 (40-

C CONDITION (POOR)

- Pasture dominated by non-preferred 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 40% at the end of the dry season)

D CONDITION (DEGRADED)

- Pasture based on non-preferred or annual plants
- 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, resulting in hostile environments for plant growth
- Moderate to poor ground cover (generally less than 40% at the end of the dry season)

History of grazing use

The area was first settled in about the mid 1800s, however the potential for improved productivity through tree clearing and infrastructure development was not realised until the mid to late 1900s.
Prior to this time, poor distribution of water points and a philosophy for fencing numerous land types into one paddock led to patch grazing and high grazing pressure around water points leading to some poor land condition areas that are evident today. This is particularly evident on the fragile duplex soils on the ironbark, box and brigalow scrubs. The bluegrass downs land types were also subject to inappropriate burning leading to a loss of bluegrass (3P) and spread of unpalatable wiregrass and weeds. The cost/price squeeze, when combined with small property size has also lead to high stocking rates in an attempt to increase productivity and meet financial demands. These are ongoing issues for the Fitzroy woodlands.

Property development with fences and waters

Most properties are well fenced and watered with paddocks greater than 2000 ha being a rarity. Permanent water points are also well spread with most cattle not having to walk more than three kilometres to water. There is most likely little potential for further productivity improvements from infrastructure development. The main benefits are improvements in efficiencies and ability to wet season spell and manage for evenness of utilisation. Significant progress has been made with fencing riparian areas, fencing to land type and installing off-stream water points.

Stocking rate management

Most properties are stocked close to the long-term carrying capacity. A minority stock too heavily and very few graziers adjust stocking rates regularly. The benefits of conservative stocking to preserve pasture and early destocking during dry periods has been consistently documented. Most producers are locked into a particular stocking strategy and do not vary by more than 10% annually. Experience with two major droughts over the last two decades has shown the benefits of early destocking.

Spelling pastures

Generally, interest is increasing for pasture spelling, however more information is needed because it is recognised as a beneficial practice. Most properties would have some form of pasture spelling occurring in most years. However, a lot of this spelling is to coincide with the herd management and marketing and not for the sole benefit of the land condition. A lot of spelling is not conducted during the growing season (November to March) and may not be for the whole growing season, and not all cattle are removed from a paddock. There is good potential for wet season spelling because of the number of paddocks available on most properties.

Prescribed burning

In the Fitzroy region west of the black speargrass zone, very little burning is done for woody weed control, changing grazing patterns or changing the composition of the herbaceous layer. Woody weed control by mechanical and chemical means is better economically because of the efficacy of the treatment and minimal or no loss of production compared with burning. There is a reluctance to burn due to the risk of not receiving adequate follow-up rain to grow pasture and the imposing legislative requirements. However, the benefits from burning are recognised for removing rank feed, hazard reduction, controlling woody weeds and coping with patch grazing.

In the black speargrass zone, burning is more prevalent for promoting green pick, controlling regrowth and altering the composition of the herbaceous layer. However, most of this burning would not be consistent with best management practice as it may be done to lengthen the growing season.

Current issues and trends

About two thirds of the Fitzroy is in good condition (A or B), and less than a third in fair (C), with some areas in poor (D) condition. This is a major issue for the Fitzroy because of the lost productivity, environmental concerns and downstream water quality. The cost/price squeeze, when combined with small property size can lead to high stocking rates in an attempt to increase productivity and meet financial demands.

Getting to know your grasses

5.1 Matching pasture supply to animal demand with land in good condition

Much of the grazing land in the Fitzroy catchment is in good condition (generally A/B). A major challenge facing managers is how to optimally use this feed 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 and profitability, but in poor years high stocking rates can give poor animal production, high costs can be incurred and pastures can degrade.

The amount of feed grown each year can vary widely due to climate variability so 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 are 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 and how often animal numbers can be altered, particularly in a breeding enterprise.

Good land condition

Poor land condition

5.1.1 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. 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 the condition of the pastures will decline. Operating in this manner can often be profitable for a number of years, until extended dry conditions are experienced. Animal production per hectare can be maximised, even though per head production is not. The resilience and stability of land in good condition can lead to 3P grass density being maintained, giving the appearance that the land resource is not suffering. Grass response to good growing conditions can also be adequate, because of the good land condition. However when extended dry conditions are experienced, the land condition and animal production will deteriorate.

5.1.2 Causes

The major cause of mismatches in feed supply and demand is the temporal variability in pasture growth rates. Pasture growth rates can vary widely both between years and during years. If stocking rates are generally higher than long-term carrying capacity, then mismatches in feed supply and demand will occur too frequently.

5.1.3 Management response: improve stocking rate management supplemented by pasture spelling and the use of prescribed fire

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 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 poor years but forgoes the extra animal production that could be achieved in good 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. Lack of knowledge on what seasonal conditions will prevail means there is no guarantee for increased animal productivity gains by increasing stocking rates during good years. There are also risks. Higher animal numbers with insufficient quantity or quality of feed can result in forced sales, extra supplement costs or lost animal condition.

Pasture spelling can also be used to alter the pasture supply and when it is consumed, and fire can assist in changing grazing patterns to prevent patches increasing. However, stocking rate management has a large bearing on the use or need for spelling, burning, weed control and supplementation.

5.1.4 Management Action: match stocking rate to long-term carrying capacity

A risk-averse approach has generally proven to be the most successful long term approach to managing stocking rates. Stocking at close to the long-term carrying capacity is equal to or less than 30% average annual pasture utilisation depending on land type. For example, brigalow with softwood scrub may sustain a safe utilisation level of 30%, while the rate for coastal teatree plains is only 15%. Stocking to the long-term carrying capacity 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 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. On the other hand, consistently low stocking rates may not be productive enough to be profitable.

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 the EDGE*network* Grazing Land Management—GLM—Manual by Chilcott *et al* 2000). 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.

Stocking rates are the key driver of animal performance and land condition, however major opportunities for improved land condition and productivity are also based around spatial distribution of grazing and targeted use of wet season spelling.

5.1.4.1 Evidence

There have been many experiments over more than 50 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 utilisation rates exceed approximately 30%. Expert knowledge has been used to develop recommended safe utilisation rates for land types in northern Australia.

There is a large international and Australian literature showing animal production per head declines, and animal production per unit area increases initially to a maximum and then declines, as stocking rate is increased. Most studies with intensively managed sown pastures have shown a linear decline in animal production per head with an increase in stocking rate (Jones and Sandland 1974) but Ash and Stafford Smith (1996) have shown 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 trial (O'Reagain and Bushell, 2011) showed that in the long-term, constant moderate stocking (25% utilisation) gave good financial returns and maintained pasture condition. Constant heavy stocking (50% utilisation) gave good returns during early wet years but not in the long term when poor seasons were experienced; it also led to poor pasture condition (Figure 1).

The Keilambete grazing trial (Silcock *et al.* 2005) showed that constant heavy stocking (50% utilisation) gave the best profitability for the seven years of this trial. While 3P grass density was not decreased, soil erosion was excessive, and ground cover, pasture yields and animal production per head were considerably less than under the 25% utilisation. At 75% utilisation, animal production and pasture parameters were further compromised, and soil erosion was unacceptably high.

The Galloway Plains grazing trial (Orr and Burrows 2011) had the best profitability at the 40% level of utilisation with native pastures only. The 50% utilisation with seca stylo was even more profitable due to an average liveweight advantage of 37 kg/steer. However, utilisation rates greater than 30% were unsustainable because they accelerated soil erosion, reduced total yield and resulted in undesirable changes in species composition. Judicious use of spring burning was also recommended to promote black speargrass populations.

The effect of grazing pressure on profitability is contrasting at these three trials. The Keilambete trial did not have extended dry conditions and the 3P grass density was maintained under increasing grazing pressures indicating a moderate effect on land condition. Galloway Plains and Wambiana trials experienced extended dry conditions and both had significant reductions in 3P grass density with increasing grazing pressure. This is further exacerbated by the length and severity of the dry season at Wambiana which detracts from recovery of perennial grasses following drought. Drought feeding costs at Wambiana were significant under 50% utilisation and severely detracted from profitability.

Therefore, profitability can be improved by stocking above the long-term carrying capacity for several years in the Fitzroy woodlands, particularly where there is a good density of seca stylo.

However, land condition is always compromised when stocking above the long-term carrying capacity, especially during extended dry conditions.

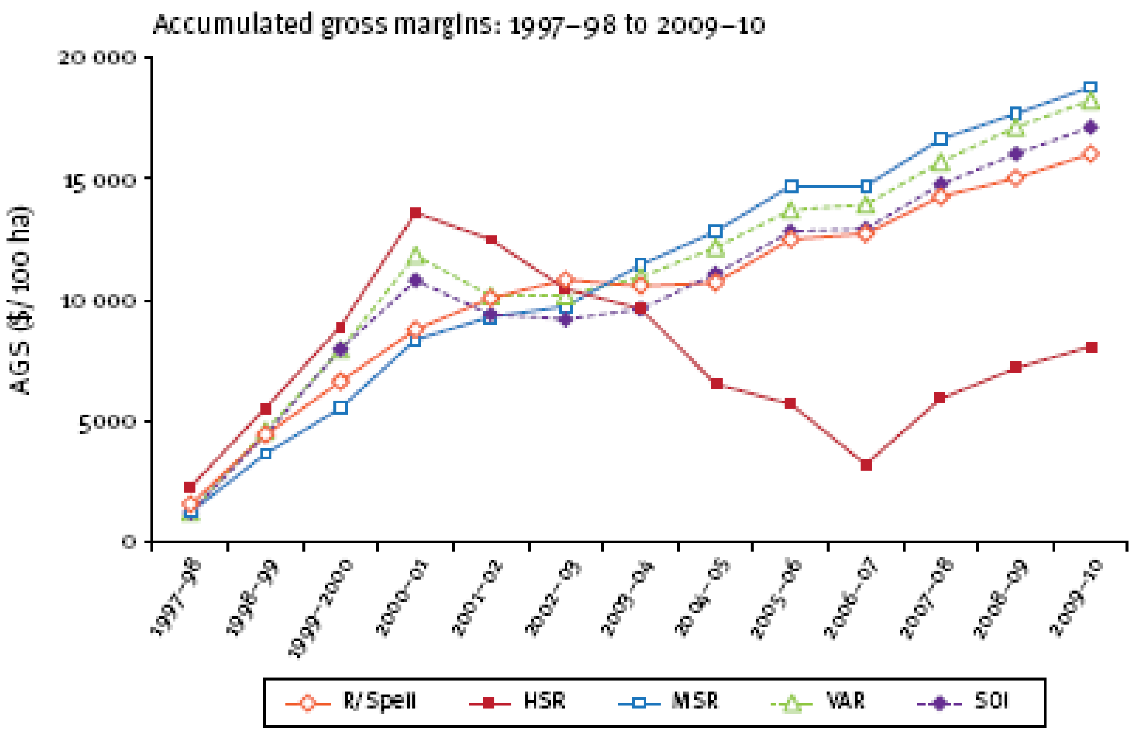


Figure 1. Accumulated gross margin (AGM) for five grazing strategies from 1997-98 to 2009-10 (assuming an interest rate of 7.5% on livestock capital)[2]. From O'Reagain et al. 2011
R/Spell is rotational wet season spelling coupled with moderate-heavy stocking; HSR is heavy stocking at twice the long-term 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).

A study examining the effects of differing grazing management intensity on nine commercial properties across Queensland from 2006 to 2009 showed the overall importance of stocking rate. (Table 4). There was no difference to land condition or the amount of cattle carried when comparing different intensities of grazing management. There was an improvement in diet quality from the continuously managed systems with 1-2 per cent higher crude protein and digestibility than the cells. These differences were largest from samples collected during the growing season and least with samples collected during the dry season (Hall *et al.* 2010).

Table 4. The effects of grazing system on pastures and animal production

	Grazing system		
	Cell	Rotation	Continuous[2]
Pasture yield (kg/ha)	2745	2620	2766
Land condition *1=A, 4=D*	2.0	2.1	2.1
Stock days/ha	113	92[1]	115
Diet crude protein (%)	7.50	7.64	8.66
Diet digestibility (%)	55	55	57

[1] Rotation data may be underestimated due to incomplete records.
[2] Continuous paddocks had some spelling.

Bio-economic modelling for a hypothetical, representative property at Duaringa was conducted over the period 1980–2006. The property was in good condition and stocked according to long-term carrying capacity. Four different stocking rate strategies were modelled. These include:

Fixed — stocking rates were constant from year to year and set to long term carrying capacity.

Current - Low flexibility — annual increases of up to 10% and annual decreases of up to 20%; long-term variation limited to 20% increase and 40% decrease.

Moderate – Moderate flexibility— annual increases of up to 10% and annual decreases of up to 40%; long-term variation limited to 120% increase and 60% decrease; and

Fully — Fully flexible – no limitations to annual or long-term variation of stock numbers, with changes directly proportional to changes in forage availability.

Current flexibility strategies allowed stock numbers to vary annually by small increases (10%) and slightly greater decreases (20%). The moderate flexibility option allowed a greater degree of variability, particularly with regards to dropping stock numbers (40%) in poorer seasons, and being able to greatly increase stock numbers when there was improvement in carrying capacity over 25 years.

The fully responsive option had no constraints on the extent to which stock numbers are changed in response to the amount of pasture at the end of May. This boom and bust strategy is the extreme to the fixed stocking management option and is unlikely to be practiced. Under this strategy, improvement in pasture only occurs when the sequence of seasons is firstly poor, with very low stock numbers, followed by good season that ensures significantly low utilisation of pasture growth. Conversely, pastures can be severely damaged when good seasons, with a lot of carry over feed, are followed by poor seasons with high grazing pressure.

Data is presented for these strategies on the fertile alluvial brigalow landtype, and the less fertile Poplar box with shrubby understorey landtype (Figure 2). Land condition was maintained for the Moderate and Fully flexible stocking rate management for both landtypes. While these stocking rate strategies can build up numbers during good years, they can also reduce numbers rapidly during dry years, prevent overgrazing and maintain land condition. The Current strategy, which did not allow rapid reductions in stock numbers when forage is low, resulted in poor land condition for both landtypes.

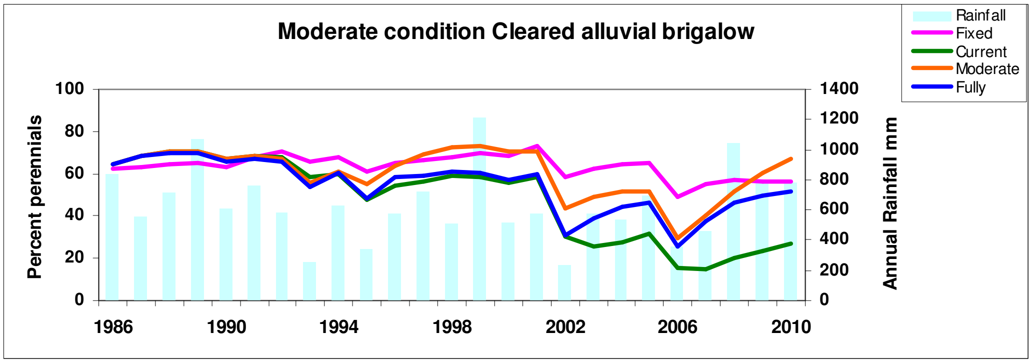
Profitability was modelled for the stocking rate management strategies. Annual profit for the different stocking rate management are presented in

Table 5. Note that the fixed stocking rate was included as a benchmark and does not indicate reality. The stocking rate was defined by the model as that which will not degrade land condition. Therefore, land condition and LTCC will be maintained even through dry years and profitability is maximised. The Fully strategy had the next highest profit, however the negative incomes were large and happened many times. The annual increases in stock numbers need to be tempered with greater drops in poorer seasons. Highly variable stocking rate strategies are a high risk financially and ecologically.

The main messages from the modelling exercise for a hypothetical property at Duaringa for the last 25 years are:

- Fixed stocking strategy, that maintains pasture condition and animal productivity is the most profitable
- Annual increases in stock numbers from the conservative stocking rate need to be tempered with relatively greater drops in stock numbers to minimise pasture degradation in poor growing seasons
- Flexible strategies are more successful at improving land condition and carrying capacity where forage variability is high and forage production low

(a)



(b)

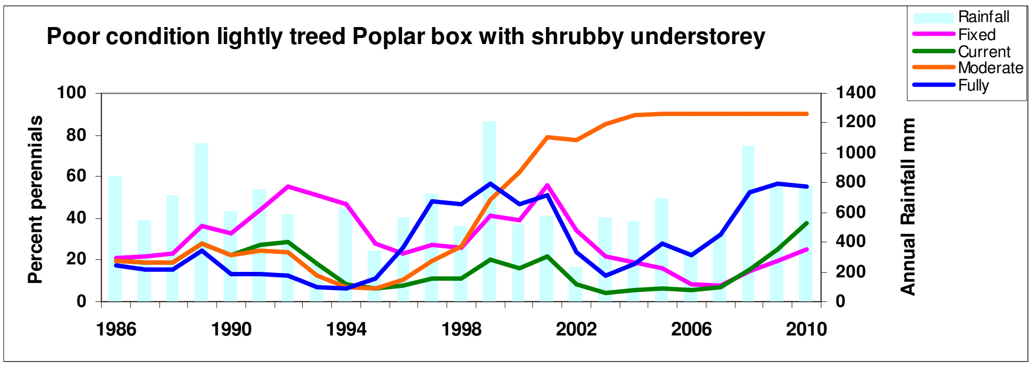


Figure 2. Stocking rate management effect on land condition (%perennials) for four stocking rate flexibility options for alluvial brigalow (a), and poplar box with shrubby understorey (b) land types from Duaringa Property, Fitzroy. Mean annual rainfall (mm) is shown.
Note—percent perennials is the composition of perennial grasses in the pasture.
A land condition ~ 80%. B land condition ~ 50%. C land condition ~ 20%. D land condition ~ 10%.

Table 5. Stocking rate management effect on profitability (annual profit)

GM/ha	Fixed Stocking Rate	Current	Moderate Flexibility	Full Flexibility
Average	$28.55	$21.78	$19.97	$24.10
Minimum	$6.67	$3.92	$2.35	$1.26
Maximum	$62.11	$38.32	$42.93	$59.39
Years – negative	0	0	0	0
NPV @ 4%	$457.44	$384.96	$362.16	$434.26

5.1.4.2 Implementation

Allow for grazing pressure from feral and native herbivores that may be present when setting stocking rates. Also discount the stocking rate according to the area of a paddock that is not accessible from water. After these discounts, calculate the long-term carrying capacity based on the average pasture growth with deductions for tree competition and lost productivity for areas of poor land condition. GLM provides training and relevant information to perform these calculations. While stocking rates will vary over time, the average should be consistent with the long-term carrying capacity. The modest amount of stocking rate flexibility is practical and manageable and—based on the modelling done to date—should maintain land condition and maximise profit. Experimental data to support this strategy is non-existent so the conclusion should be considered preliminary.

Large cumulative reductions in stock numbers—for example during an extended dry period— should be carefully planned to allow for effects on overall herd dynamics, cash flow and availability of working capital. Specialist financial advice should be sought. There will likely be some cost saving through reduced supplementary feeding for example. Improved herd productivity will most likely result from reducing stocking rate and this needs to be used to maximum advantage.

5.1.4.3 Considerations/caveats

Stocking rate is the major factor driving land condition and animal production through its effect on annual utilisation rates. Where the landholder has determined that stock numbers are higher than the long-term carrying capacity, then maintenance of these numbers will eventually result in reduced profitability and deterioration of land condition.

On the other hand, the timeframe for repair of pastures being patch grazed due to reduced stocking rate is not predictable. Above average growing conditions and wet season spelling may also be necessary for tangible improvements.

Grazing method is relatively unimportant compared to the importance of stocking rate. When stocking rate is matched to long term carrying capacity, improved land condition will mainly be achieved through better spatial distribution of grazing and use of wet season spelling.

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

Following on from the previous section, some adjustment of stocking rate around the long-term carrying capacity appears to be necessary to ensure good pasture condition and to improve profits. 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, however 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 decades. It is wise to set an upper stocking rate limit even for very good seasons to avoid excessive pasture utilisation rates. This upper limit should not exceed about 50% annual pasture utilisation in the more productive land types. In the less productive land types, this upper limit should not exceed 20% annual pasture utilisation.

Seasonal forecasts can be used in several centres in the Fitzroy. The Rainman StreamFlow program shows that the SOI can be used to assist stocking rate decisions for the coming summer for centres such as Duaringa, Rolleston and Rockhampton. However, remember the limitations of seasonal forecasts and be prepared to adjust for different conditions. Estimates of expected pasture production based on historical records can be used where seasonal forecasts are not reliable.

In the Fitzroy region, rainfall and pasture growth can be unpredictable and a more tactical approach to setting stocking rates may be useful. Adjustments are made on an ongoing basis in response to changing conditions. This approach requires the capacity for a considerable degree of flexibility in stock numbers, but it can allow for best use of forage when it is available and protection of the land when seasonal conditions are poor.

5.1.5.1. Evidence

Wambiana grazing trial (O'Reagain and Bushell, 2011) is the only site to experimentally compare variable stocking rates, where animal numbers are changed each year at the end of the growing season, with strategies approximating set stocking. The variable stocking regime gave no net advantage due mainly to problems (both financial and declining land condition) in the transition from good to poor years.

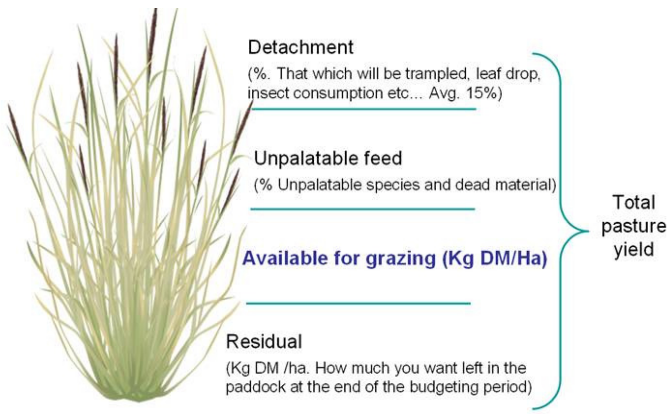
A number of trials have been conducted over the past 30 years examining the effects of utilisation rate on pasture performance [Ecograze (spear grass), Toorak (Mitchell grass, Burenda (Mitchell grass), Arabella (mulga)]. While the method of determining utilisation rate varied between studies (consumption 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 do show declines in both animal production per head and pasture condition as utilisation rate increases.

5.1.5.2. Implementation

Stocking rates should be reduced 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.

Develop a forage budget at the start of each dry season for the coming 12 months. This should allow for adequate pasture residue (800–1000 kg/ha, 40–70% ground cover) at the start of the next wet season and for the possibility of a poor wet season. Tools such as Stocktake are available to help in developing a forage budget. When doing a forage budget, estimate the amount of feed left at the end of the growing season. Unpalatable pasture, residual feed that should be left as ground cover at the beginning of the growing season and pasture that will be lost due to trampling and wastage should now be subtracted. What is left is available for grazing (Figure 3). Seasonal forecasts can be combined with estimates of standing forage biomass at the end of the wet season to determine stocking rates for the coming 12 months.

Figure 3. Components of a forage budget



Adjust stocking rates twice a year if necessary (at the start and end of the dry season). There are significant detractors from trying to sell stock at the end of the dry season. Stock are often not in best condition and demand is often poor. Where it is feasible, reducing stocking rates during the wet season if rains are poor can help protect pasture condition.

Stocking rate decisions should be based on an assessment of current pasture conditions. This should consider patterns of grazing distribution within paddocks. Ground cover should never reach a low of 30%. Ideally, ground cover should be between 40–70% at the end of the dry season. For most land types this equates to a pasture yield of 800–1000 kg/ha. These benchmarks inform decisions about reducing 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 for protecting the soil.

5.1.5.3. Considerations/caveats

Good growing seasons with an ample supply of feed may provide an opportunity to spell pastures to maintain condition and/or to use fire to manage woody plant populations (see section 5.7). Spelling pastures allows the health and vigour of 3P grasses to improve as root systems and crown cover increase. The extra body of feed ensures a safety net for maintenance of ground cover should the next wet season be lacking.

Forage budgeting at the beginning of the wet season is only a guide because of the uncertainty associated with seasonal forecasts. However, the value in forage budgeting is the alerting and avoidance of worse case scenarios. Where pasture levels are low, forage budgeting calculations allow planning the management of stocking rates well before animal production starts to deteriorate.

5.1.6. Management action: implement pasture spelling

Spelling 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 spelling also has a role to play in maintaining and restoring pasture condition. Patches that have been overgrazed are able to recover which will assist with evenness of grazing. 3P grasses also obtain a competitive advantage over the less desirable and less productive plants such as wiregrass and Parthenium.

5.1.6.1. Evidence

There has been little study of the effects of pasture spelling on land in good condition (see section 5.5). One of the few studies was the Ecograze project at Charters Towers where spelling paddocks in the early growing season each year for eight weeks combined with 50% utilisation gave similar pasture performance to 25% utilisation without pasture spell. Both these treatments maintained land in good condition.

Pasture spelling 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 especially if spelling is combined with fire.

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

5.1.6.2. Implementation

Where the aim is to grow more feed then spelling will need to be during the growing season but if the aim is to reduce consumption then this can be any time during the year. Where a number of paddocks have similar long-term carrying capacity, spelling can be implemented by spreading the herd from the spelled paddock over the remaining paddocks. For example, with a four herd, five paddock system, each paddock would get a spell every five years if seasonal conditions permit. On fertile land types in good condition, spelling is generally not needed at low to moderate stocking rates. For the less fertile land types in poor condition, a full WSS every two to four years may be necessary to improve land condition, especially at higher stocking rates. The duration and frequency of spelling needed for recovery will be less when taking advantage of good seasons. The benefits of spelling may not be as noticeable if the rotation is to begin during a run of poor seasons.

5.1.6.3. Considerations/caveats

Although the aim of spelling in this case is concerned with the amount of feed available for animals, spelling may give additional benefits in terms of maintaining or improving land condition. In reality, spelling management will entail logistical challenges and there is little if any evidence to guide the implementation of spelling actions.

5.1.7. Management action: implement a prescribed fire regime

Fire can be used to influence where animals graze and encourage them to leave grazed patches and graze elsewhere. Development of woody weeds problem and subsequent reduction in long-term carrying capacity can be avoided with prescribed fires.

5.1.7.1. Evidence

There is both experimental evidence (e.g. Andrew 1986) and a lot of practical experience that animals prefer burnt areas that are regrowing than unburnt areas. A local example of how this management action has been successfully implemented comes from a grazier at the Willows who has predominantly silver-leaved and narrow-leaved ironbark on hills and ranges. He has successfully evened out grazing distribution in very large paddocks by burning on the top of ridges to attract cattle to rank ungrazed pasture. Another grazier in the Rubyvale area has employed similar management on a silver-leaved ironbark property that has been in the one family, and had the same fire management for 100 years. Usually one third of a paddock is burnt so that the patch grazing on this area ensures the remainder of the paddock is spelled. Subsequent burns target different areas of the paddock. Combined with a conservative stocking rate, the land condition is very good.

5.1.7.2. Implementation

Usually about one third of a paddock is burnt, after 38–50 mm of grass growing rain early in the wet season. This practice is best done when there are above average levels of forage, and should be combined with information from forage budgeting to reduce risk of running out of feed. Ideally it is done when forecasts for above average rain are good. During years of above average forage levels this practice also serves the purpose of hazard reduction.

5.1.7.3. Considerations/caveats

As stated above, this practice is only relevant to small areas of the Fitzroy woodlands where paddocks are large and patch grazing is a problem, or where areas are water remote. It is an effective practice that can alter grazing distribution and also serve to suppress developing woody weed problems. Where follow-up rainfall is lower than expected, then the grazing distribution can be focused on these areas for several years. This can be an undesirable outcome because the area of rank grass can become a patch grazed area. This is particularly relevant where there are several years of below average seasonal conditions. One method to reduce the risk is to only burn in La Nina years, when the probability of above average summer rainfall is high. Never burn during El Nino years.

5.2 Pasture in poor (C) condition

Section 5.5 referred to a situation where a paddock is in good overall condition but there are some patches in poorer condition and the pasture may be commencing to deteriorate. In this section we are dealing with pastures where this process has continued and the paddock is now in poor condition. Section 5.7 deals with land in poor condition due to too many woody plants.

The question for land in C condition is how to manage animal numbers to minimise periods of feed shortage while using pasture spelling (and sometimes fire) to improve land condition.

5.2.1. Signs

Most of the paddock or particular parts of the paddock (e.g. preferred land type) are in C condition. Pastures that have declined in the Fitzroy are generally on very fragile soils, or where cattle have patch grazed due to the area being both low in the landscape and having a longer growing season than adjoining hillslope areas, and also being in close proximity to natural permanent waters. Most of the 3P grasses have been lost from the pasture which is now dominated by less desirable (but possibly still useful) grasses and forbs. Feed shortages may develop quickly in dry periods although high nutritional quality feed may be available for short periods. Soil surface condition may be deteriorating with some erosion and significant loss of moisture through runoff. An example of this is the silver-leaved ironbark on duplex soil land type. Poor land condition is demonstrated with some loss of the 3P grasses desert Mitchell grass and black speargrass, while slender chloris summer grasses, button grass, five minute grass and sedges may be increasing. Pasture yields can be low but sometimes pasture composition can still be OK (high proportion of 3P grasses). C condition land is also expressed if the 3P grasses are small and widely spaced with low vigour, ground cover is poor with deteriorating soil surface condition, and there is some erosion and significant loss of moisture through runoff. Animal production will be reduced. On the bluegrass downs land type, C land condition can be expressed with a pasture dominated by perennial undesirable species such as unpalatable grasses and forbs. 3P grasses are still present in small amounts and ground cover is good.

5.2.2. Causes

The primary cause leading to poor land condition is usually chronic and continuing overgrazing which may be exacerbated by drought and/or intense wildfire events. 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 and intense wildfire can sometimes enhance damage to already weakened pasture.

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. windmills grasses) or species with unpalatable traits (e.g. wiregrasses, Parthenium, giant rats tail grass) resulting in avoidance by livestock. Unpalatable traits may include tough leaf blades and stems, chemical deterrents or physical deterrents (prickles and spines).

5.2.3 Management response

Manage animal numbers to minimise periods of feed shortage while using pasture spelling (and sometimes fire) to increase the 3P grasses, reduce undesirable species and improve ground cover and rainfall infiltration. The management challenges faced with this recommendation are not addressed specifically in the following sections.

5.2.3.1 Management action

If the amount of pasture is low but pasture composition is reasonable (high proportion of 3P grasses) but they are small, widely spaced, low vigour 3P grasses, ground cover is poor with deteriorating soil surface condition, with some erosion and significant loss of moisture through runoff, this is a common scenario for C condition pastures in the Fitzroy woodlands.

The main objective in this situation is to encourage the 3P grasses to increase in the pasture and minimise the loss of soil and moisture in runoff.

The most effective actions will be pasture spelling combined with matching stocking rates to forage available. Installing additional infrastructure may be useful to move stock away from preferentially overgrazed land types or to enable the application of pasture spelling. Fire is unlikely to be an important action in this scenario except for specific purposes such as black spear grass growth and recruitment or to encourage grazing of rank patches.

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). Spell that is aimed to benefit pasture condition targets both the health and reproduction of individual plants and the overall land condition.

A general recommendation for improving pasture condition is to have a planned but flexible regime to spell paddocks for the whole growing season commencing from the first rain event sufficient to initiate new growth (38–50 mm in three days). Spelling regimes can be described by their timing (seasonal), duration and frequency or number of spell 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. Spell during the dry season may also be useful for maintaining ground cover and improving rainfall infiltration for the following growing season.

The duration of spell period for poor condition pastures should be a minimum of eight weeks for maximum vegetative growth. Spelling for the whole growing (wet) season has many benefits. 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. Seedlings require time to grow a strong root system with reserves to allow survival in the following dry season.

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

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

Minimal gains will be made with spelling if following the spell period stocking rates are not matched to feed supply and ongoing overgrazing occurs. Section 5.5 describes how to match pasture supply and animal demand.

Fire has been used to spell parts of paddocks as animals prefer to graze recently burnt areas in preference to non-burnt areas. This will give some spelling to the non-burnt areas and has been effective under experimental conditions but its effectiveness under commercial conditions is unknown. The animals do not graze exclusively on the burnt areas so there will be some grazing (and possibly continuing deterioration) on the non-burnt areas. Where only small areas are burnt the concentration of grazing on this small area may also do more harm than the benefit derived on the non-burnt area.

Fire can be used to remove old patches of dry mature herbage so that all young material is equally accessible. However, if these patches are in poor (C) condition, caution needs to be exercised if soil condition and ground cover are to be compromised. Patch burning can aid even grazing and prevent continued selective grazing of existing poor condition patches. However, burning removes the feed supply and if seasons are poor can lead to heavy grazing and the need for additional spell. Poor seasons can also lead to the burnt area being patch grazed for several years.

5.2.3.2 Evidence

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.

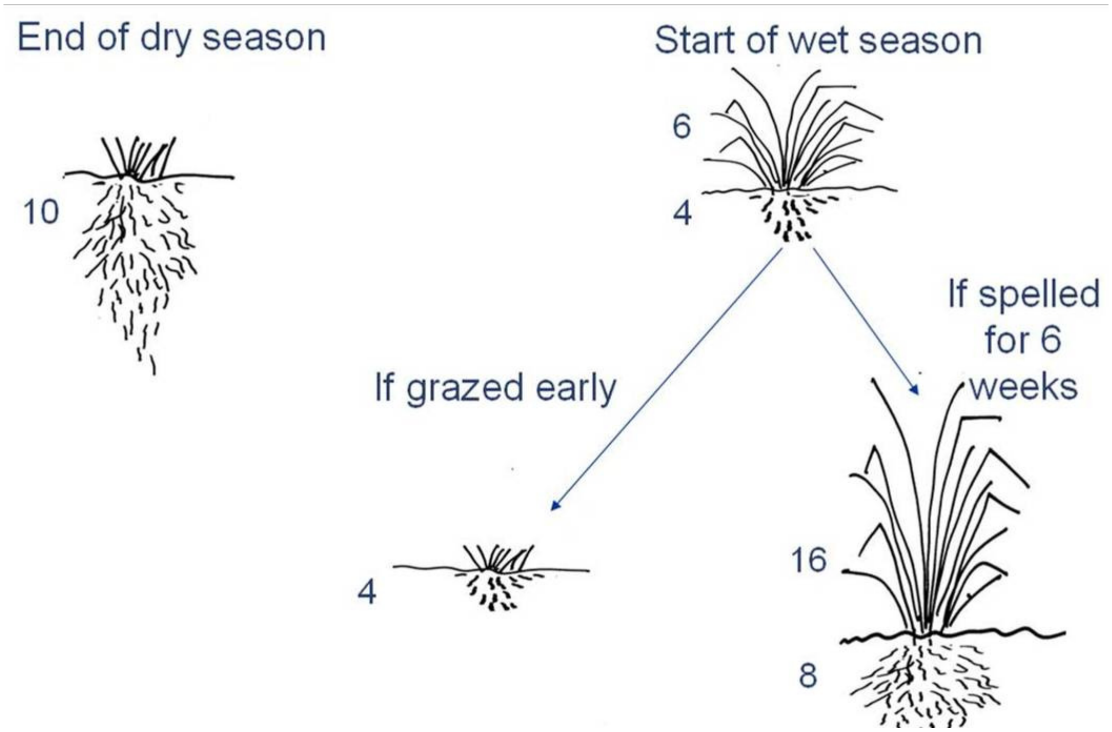


Figure 4.. The energy left in a 3P grass at the end of the dry season (e.g. 10 units) is redistributed differently according to early wet season grazing or spelling, affecting how well the grass will grow over the rest of the wet season.

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 4). Seedlings require time to grow a strong root system to survive the following dry season.

Bio-economic modelling was conducted for a hypothetical property at Duaringa. It allows an examination of the grazing management factors that influence land condition improvement. Cleared paddocks with the Box flats land type in C land condition were modelled for the following combination of spelling treatments:

- No spell, two month, three month and six month spell starting on the first of December.
- Spelling every year, three out of four years, every second year and every fourth year.
- Stocking rates were 5.6, 4.5, 3.9 and 3.2 ha/AE.
- Long-term carrying capacity for this paddock is equivalent to 4.5 ha/AE.

The models were run for 20 different 30–year sections of the historical climate records.

The simulations suggest that recovery of land condition was possible but was very dependent on the seasonal conditions at the start of, and during, each period. The interaction of stocking rate, climate, duration and frequency of spelling is important for recovering land condition. At low stocking rates, recovery requires a six month spell every second year. At higher stocking rates, recovery requires a six month spell three out of four years. A two month spell every four years may be effective if there are good pasture growing conditions. The duration and frequency of spelling needed for recovery will be less when taking advantage of good seasons. While there is a lack of anecdotal evidence regarding significant improvements in land condition, this data was presented to a consultative group of experienced graziers and agency personnel who found the outcomes quite acceptable.

The profitability of spelling was also modelled for four paddocks on the hypothetical property at Duaringa for 1980 to 2006 (Table 6). Four breeder paddocks with poplar box land types were in poor condition and rotationally grazed with each paddock receiving a six month spell every four years. The herd from the spelled paddock were agisted 100 km away for the six months. The main benefits were an improvement in land condition on the box land type which allowed a 50% gain in LTCC after eight years. The same improvements occurred after 16 years on the less productive poplar box with shrubby understorey land type. This was compared to a 'no spelling' treatment where land condition continued to deteriorate. Paddocks were stocked at long-term carrying capacity with the 'Current' stocking rate management. The improvements in profitability have occurred due to the increased carrying capacity as land condition improves with spelling. This is despite the annual agistment costs.

The spelling treatment improved the average gross margin per hectare, as well as the Net Present Value.

Table 6. Spelling management effect on profitability

GM/ha	No spelling	Spelling[1]
Average	$22.32	$28.26
Minimum	$11.51	$13.88
Maximum	$31.72	$42.33
Years – negative	0	0
NPV @ 4%	$370.37	$442.62

[1] Includes agistment and freight costs

The 4th paddock problem involves a four paddock rotation where paddocks are similar in size, land types and LTCC. Each paddock gets spelled every 4th year with the other paddocks having an increased stocking rate of 33%. Therefore the 4th paddock is the last paddock to be spelled, and can end up in poor condition. During dry years the 3rd paddock can also end up in poor condition.

While this problem is not easily addressed, there are potential solutions. The first priority is to allocate spelling based on the land condition. The poorer land condition paddocks get spelled first, while paddocks with good land condition are spelled last. Paddocks with good land condition are more stable and resilient to withstand higher stocking rates. Another suggestion is for the stock from the spelled paddock to be agisted for the first four years of the rotation. This allows an improvement in land condition prior to the rotation operating as originally suggested.

The below sites are a good example of land condition improvement. They are located on Rubyvale miners' common and had previously been heavily overgrazed. The paddock was then subject to one full wet season spell (2003/04 summer) and stocked continuously to long-term carrying capacity which has resulted in an improvement in land condition over time (Figure 5).

September 2003 September 2010

Figure 5.. Land condition improvement at Rubyvale. Box flat land type above, and silver-leaved ironbark land type below. The box flat has improved the crown cover and composition of desert bluegrass (3P). The silver-leaved ironbark land type has improved the crown cover and composition of buffel grass (3P). The silver-leaved ironbark site was burnt accidentally in spring 2009.

5.2.3.3 Implementation

Spelling to recover land in poor condition

Paddocks with significant areas of C land condition should be managed with a spelling regime as a priority to improve land condition. As land condition improves. long-term carrying capacity and profitability will improve. Conservative stocking rates combined with a six month spell every second year should be aimed for. If combined with some reasonable seasonal conditions, recovery to A land condition should be expected within ten years. This recommendation is based on modelling outputs and industry consultation.

Spelling a paddock will inevitably result in other paddocks carrying extra stock and increasing stocking rates above the long-term carrying capacity. This situation arises where the mobs from four paddocks are spread over three paddocks, so that each paddock receives a spell every fourth year. The paddocks not being spelled are carrying about a third more cattle. Paddocks in the best condition should be the last in the system to be spelled. The paddocks in the best condition will be the most stable and resilient to accommodate the extra cattle. Similarly the C condition paddocks should be the highest priority for spelling.

For properties that have only a few paddocks, a more intensive rotation may be required to achieve the desired frequency of spelling. For example, if the cattle in six paddocks are put into one mob and grazed on a rotation through the six paddocks, shifting every two to six weeks, each paddock will get a spell in some part of the growing season in most years. Initial stock numbers need to be determined from the long-term carrying capacity, and a forage budget should be conducted at the end of the growing season to ensure there is sufficient feed available to get through the dry season with sufficient ground cover to start the next wet season.

Another consideration when considering the management of a spelling regime is the improved diet quality cattle obtain from continuously grazed systems. A 10% improvement in diet quality (and potentially growth rate) can be achieved with a continuously grazed system when compared with intensively managed systems. Improvements in diet quality can still be achieved with rotations as long as paddocks are large and cattle are able to stay in the paddock for a long enough period to exhibit their desired diet selection. Information is not available on the specifics of how to manage rotations for diet quality improvement. However, diet quality can be monitored through commercial assessment of faecal samples.

Regardless of the class of cattle being rotated, the objectives of the rotation should be:

- Achieve frequent wet season spells (every second year).
- Maintain land condition of the paddocks not being spelled.
- Minimise the intensity of the rotation to maximise diet quality.

Minimising the intensity of rotation of spelling is desirable for breeders to avoid movements while calving, and potential mismothering problems. It is also desirable for growing cattle to maximise diet quality and potential growth rate.

5.2.3.4 Consideration/caveats

Stocking rate is the major factor driving land condition and animal production through its effect on annual utilisation rates. However, there is a lack of data on the effects of different spelling strategies on sustainability and profitability, and the processes at the soil/plant interface with land condition improvement. Where the landholder has determined that stock numbers are higher than the long-term carrying capacity, then maintenance of these numbers will result in reduced profitability and deterioration of land condition.

On the other hand, the timeframe for improvements in land condition due to reduced stocking rate—or spelling strategies—is not predictable. Above average growing conditions and wet season spelling may also be necessary for tangible improvements in land condition. Remember that as land condition improves, so will the long-term carrying capacity, and long-term carrying capacity should be reassessed accordingly.

5.3 Woody plant problem

In the Fitzroy woodlands, many different natural or semi-natural plant communities are used as pastures for the grazing of cattle. Most of these grazing systems depend on vegetation that includes some woody species, both trees and shrubs. The make up of this woody component varies greatly both within and between vegetation types, in terms of the overall density and biomass of woody plants, the structure of the woody strata and their species composition.

Woody species differ in their growth form, mode of reproduction and reproductive output, mode of dispersal, recruitment patterns and longevity. They also differ in their palatability to different types of herbivores (including livestock) and their responses to different types of disturbance. Browsing and fire, as well as other kinds of shoot damage, will influence different species, or even different individuals of a species, in different ways. All these factors make for enormous spatial variation in the woody component of the Fitzroy catchments vegetation. They also demonstrate large temporal dynamics at various time-scales.

Although the woody components of the Fitzroy woodlands are naturally dynamic, in many areas there is concern that since pastoral settlement there has been a trend to increasing woodiness of the vegetation. This increase comes from three sources:
(i) thickening of native understorey species
(ii) thickening of native upper storey species
(iii) invasion of non-native trees, shrubs and woody vines.
Different species are involved in different locations and often there are multiple species involved.

Most of the woody plants in the Fitzroy woodlands have some ability to resprout following burning. Poplar box, silver-leaved ironbark, narrow-leaved ironbark, sandalwood, brigalow and most wattles resprout from growing points on the stems, lignotuber or roots. There is minimal mortality from a one-off fire and while the above ground biomass is reduced, most of these plants survive. Repeated fires may induce higher mortalities. Cypress pine, on the other hand has limited ability to resprout and high mortalities are achieved from burning. Regrowth is from seed, and will be minimised by strong grass competition and follow-up fires. Lancewood and some other wattles also have limited ability to resprout and high mortalities are achieved by burning, however, burning is a very rare occurrence on lancewood ridges, and can be followed by an incursion of poisonous weeds. Burning is also thought to encourage wattle germination through damaging the hard seed coat and allowing the seed to be imbibed with water. Hickory wattle, yellow wattle and black wattle can regrow from root suckers and seedlings. Sally wattle and Brigalow regrow prolifically from root suckers and seem to have little regeneration from seed.

Why is the proliferation of native or non-native woody species a problem in pastoral lands? Woody plants can be problematic for pastoral production from natural or semi-natural vegetation. The following are the major issues, though their absolute and relative importance certainly varies from one situation to another:

- Woody plants can compete with more palatable or more nutritious forage and so reduce the carrying capacity of the vegetation.
- Some woody plants are toxic to livestock.
- Dense stands of woody plants can inhibit the access of livestock to water.
- Dense woody vegetation can interfere with efficient animal husbandry e.g. mustering.
- Woody vegetation may provide harbour for pest animals such as feral pigs.

It is also true that some species of woody plants, both native and non-native can provide both useful browse which may contribute significantly to livestock diets, and shade. Invasion by the non-native Parkinsonia as well as many native woody species has invoked a great concern by graziers.

Silver-leaved ironbark at Anakie was found to have no negative effects on pasture growth despite medium tree densities. This was also recognised by graziers in the district who were adamant that tree clearing was not worthwhile. Possible reasons for the lack of tree effect on pasture growth could be that the silver-leaved ironbark trees had minimal foliage volume. When compared to Poplar box trees, which are renowned for being competitive with pasture, the silver-leaved ironbark trees had approximately half of the canopy volume. Therefore, the ability to photosynthesise and withdraw moisture from the soil would be considerably reduced, resulting in a reduced competitive effect on pasture growth.

5.3.1. Signs
The relationship between woody and herbaceous plants is a critical one. In general, the biomasses of woody and herbaceous components of the vegetation are inversely related to one another: all else being equal, higher woody plant biomass is associated with lower herbaceous biomass. The size, number and distribution of woody plants can all be useful indicators of the

impact that woody plants are having on the herbaceous layer. 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. 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 useful and reliable information. 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. The presence of species such as rubber vine (*Cryptostegia grandiflora*), prickly acacia (*Acacia nilotica*), and parkinsonia (*Parkinsonia aculeata*), which are known invasives, indicates a threat of increasing non-native woody weeds.

5.3.2. Causes

Many factors drive tree and shrub populations. Some of the important ones are indicated in Figure 6, which portrays the dynamic balance between woody and herbaceous (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
- rising CO2 levels—as suggested in some literature.

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 effective fire becomes less likely. This feedback loop is exacerbated by the negative effect of increasing woodiness on fuel loads.

5.3.3. 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 6) as herbivores and fire, in effect, compete for herbaceous material. Prescribed burning, then, constitutes a management response to increasing woodiness of northern Australian vegetation.

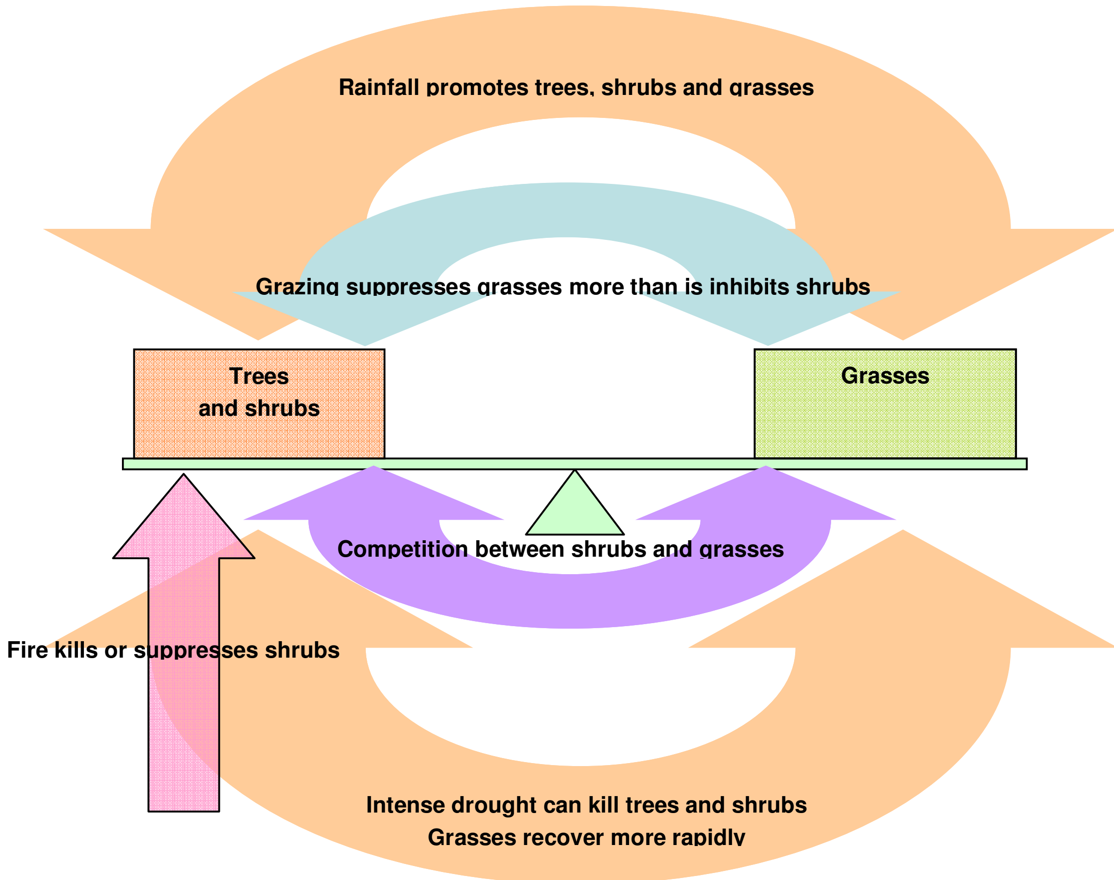


Figure 6. Factors affecting tree and shrub populations.

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

If it is judged that woody plants are reaching densities or a biomass that is detrimental, prescribed burning is one of the options open to land managers. 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. Regrowth control, increasing densities of trees and shrubs in non-cleared areas and managing commercial timber species in the sub-coastal ranges are important issues in the Fitzroy woodlands.

5.3.4.1. 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.

Burning trials on currant bush in central Queensland, black wattle and *Acacia grandifolia* in the Burnett region have shown how repeated fires can suppress these woody weeds for up to seven years. *Acacia grandifolia* regrew from seeds, while black wattle regrew from root suckers, and currant bush regrew from resprouts and layering.

Bio-economic modelling for a hypothetical, representative property at Duaringa was conducted over the period 1980–2006. The property was in good condition and stocked according to long-term carrying capacity. This was termed the 'Modest flex' management which is presumed to reflect current practice where total numbers are usually only varied by 20% in any year, but not more than 40% in total numbers; variation was driven by the model calculating in May each year the stocking rate that would use 30% of standing pasture over the subsequent 12 months. Four paddocks with the box flats land type were modelled to determine how frequent cool and hot fires could be conducted when there is varying tree cover. Cool fires were defined as having a fuel load of 800 kg/ha, and hot fires had 2000 kg/ha. With no trees present, cool fires could be implemented in more than 50% of years, and hot fires in more than 40% of years. With trees present, the frequency of cool fires decreased to 20% of years and hot fires to 10% of years. Land condition was sustained at higher levels in the burn treatment because tree density was kept low for most of the period (Figure 7 and Figure 8).

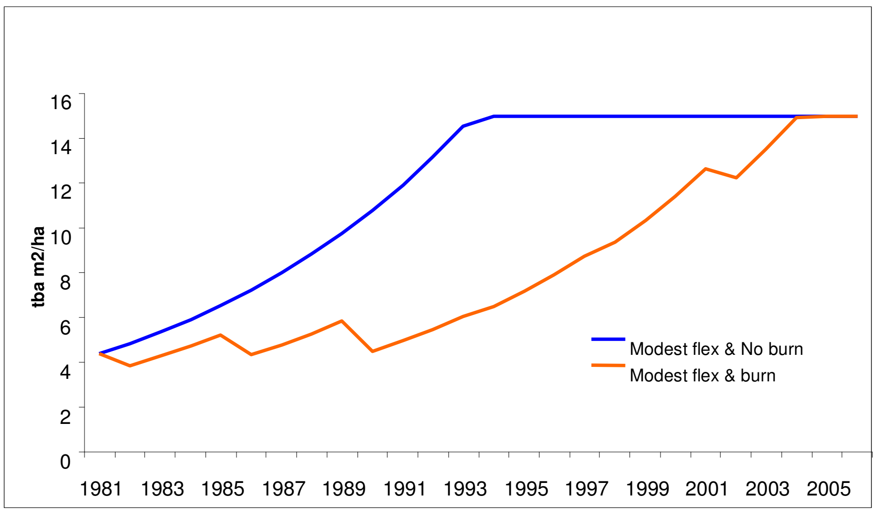


Figure 7. The effect of burning on tree density

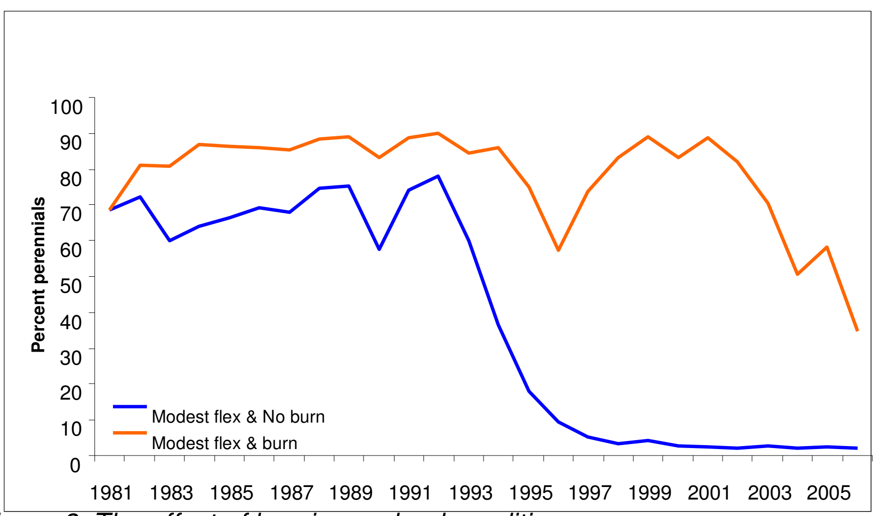


Figure 8. The effect of burning on land condition

The profitability of burning was also modelled for four paddocks on the hypothetical property at Duaringa (Table 7). Four paddocks of box flats land type in A land condition were burnt once in every fourth year. This was compared to a 'Modest flex' management which is presumed to reflect current practice where total numbers are usually only varied by 20% in any year, but not more than 40% in total numbers; variation was driven by the model calculating in May each year the stocking rate that would use 30% of standing pasture over the subsequent 12 months. The fire treatment improved the profitability measured by GM/ha and NPV. The fire treatment was able to suppress the tree density and therefore increase land condition and long-term carrying capacity. This effect was maintained for most of the modelling period resulting in the improved profitability.

Table 7. Burning management effect on profitability

GM/ha	Modest flex	Fire
Average	$21.59	$24.87
Minimum	$0.49	$3.83
Maximum	$49.67	$52.44
Years - negative	0	0
NPV @ 4%	$386	$429

Some common woody weeds in the Fitzroy and their responses to fire are listed in Table 8.

Narrow-leaved ironbark landtype at Dingo burnt to prevent woody thickening and improve animal production

Table 8. Common woody weeds in the Fitzroy, their susceptibility to fire and the types of fire needed for their control.

Woody species	Susceptibility to Fire	Intensity and frequency of fire required	Additional comments
Brigalow	Low	Hot fires every 5–7 years	Fire will help to suppress regrowth and increase the time until mechanical control is needed
Poplar box	Seedlings—High Plants taller than 1.5 m—Low	Cool fires every 3–5 years will maintain open woodlands	Small plants are often several years old, have a well developed lignotuber and are resistant to fire
Silver-leaved ironbark	Seedlings—High Plants taller than 1.5 m—Low	Cool fires every 3–5 years will maintain open woodlands	Small plants are often several years old, have a well developed lignotuber and are resistant to fire
Currant bush	Low	Cool fires every 3–5 years will maintain open woodlands	Currant bush spreads by layering, which can be encouraged by burning
Wattles	Low	Cool fires every 3–5 years will maintain open woodlands	Wattles regrow rapidly by seed, root suckers or both.
False sandalwood	Low	Medium intensity every 4–7 years	Fire kills very few sandalwoods but will suppress regrowth

5.3.4.2. 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 years in which fuel loads are adequate.

Paddocks should be prioritised for burning with grazing and spelling strategies planned to make best use of the years which are suitable for burning.

Consultations with graziers and agency personnel came up with the following burning management recommendations:

- Assessing the need for fire. The use of fire should be targeted, with clearly defined objectives identifying the species of woody plants to be managed and the fire regime (type, frequency, intensity) to be applied.

- Accumulating at least 2000 kg/ha of pasture biomass as fuel, suitably distributed across the target area(s). Fires should be timed to take advantage of seasonal conditions that facilitate the accumulation of fuel and minimise effects on short-term carrying capacity. Pre-fire spelling of pastures intended for prescribed fires may be necessary depending on the seasonal conditions. Forage budgeting at the property scale will be helpful here. It may be necessary to spell during the growing (wet) season to ensure adequate fuel accumulates and during the subsequent dry season so that fuel persists until the time of the fire.
- Planning and constructing appropriate fire breaks well in advance of burning.
- Ensure adequate and suitable equipment and labour are available and necessary permits are obtained.
- Burning late in the dry season. Choose the precise time of the fire by considering wind, temperature, humidity, fuel moisture levels and fuel continuity. The aim is to produce a fire with a long residence time at the base of trees and shrubs. The most appropriate fire may be a ‘head’ fire or a ‘back’ burn depending on conditions.
- Continue spelling into the post-fire period to ensure grazing does not damage pasture plants as they recover from the effects of burning. This will be especially important if the immediate post-fire wet season is a poor one.
- Re-burning the area within one to three years depending on the rate of fuel accumulation. A fire regime that involves burning twice in quick succession (either in consecutive years or in years one and three) is likely to be more effective against woody plants than a single fire.
- Reassessing the need for further burning by five years after the second fire, and in subsequent years. A regime of two fires every ten years may be necessary but do not burn unnecessarily. Take advantage of seasonal conditions in deciding when to burn.
- Burn up to 10% of the property annually.
- Common for burns to occur after September or Spring rain.
- Burn to land type—flatter country early in the season and the hills later.
- Burn in good years, not in dry years.
- Need to spell after fire, although this could not be done when burning only parts of paddocks (mosaic burning).
- Spell paddocks before burning.
- Slow burns may be more effective for woody weed control, compared with a fast moving fire.
- Use fire to spell some parts of paddocks, especially very large paddocks – burn and remove feed to move stock elsewhere.
- Burn to cope with patch grazing, to remove rank feed and for hazard reduction.

5.3.4.3. Considerations/caveats

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 spelling of pastures that is required in order to build up fuel loads so that an effective fire can be achieved. 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. Also, fire can promote germination of some woody species, notably *Acacia* spp. It is important to monitor the area in the post-fire period in order to be able to respond appropriately to large-scale germination events. If large recruitment events are triggered by a fire, a second fire may be useful. Conducting a second prescribed fire before recruits set seed could reduce the build-up of seed-banks of species such as *Acacia* spp.

Other risks which were identified by consulting graziers and agency personnel include:

- The risk of not receiving adequate follow-up rain to grow pasture and replace that which was burnt.
- Risky to burn before rains, as may not get recovery for two or three years if strike a dry few years.
- Lack of fuel.
- Less use of fire now and more reliance on stock to remove feed.
- Fire was used much more during the early years of development, when people were pulling country—was used to clean up logs.
- Burn less often now that paddocks have buffel and legumes—burned more when had native pastures.
- Cold or hot fires don't always work the way you think they should—unpredictable.
- Some believe you can get more regrowth after fire e.g. Brigalow.
- Liability
- Legislation
- Uncertain impacts.

Not surprisingly, large areas of the Fitzroy are not using fire.

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

For systems in which the incorporation of fire is the preferred option for managing woody plants, it is critical to integrate grazing and fire regimes. Heavy grazing over long periods may facilitate an increase in woody plants by reducing the competition that woody seedlings face from palatable herbaceous perennials. It would also reduce the opportunity for conducting prescribed fires. Matching stocking rate to long-term carrying capacity increases the window of opportunity for incorporating effective fire into the management system.

5.3.5.1. Evidence

Fire and grazing clearly compete for grass biomass. The general relationship between stocking rate and herbaceous biomass is well established though the specifics vary between land types and climatic zones. Accepting 2000 kg/ha as a minimum fuel load for an effective fire for woody plant management, this threshold will be reached more frequently in higher rainfall zones or on the more productive land types, and where stocking rates are lower. Grazing by feral and native herbivores influences herbage availability in the same ways as domestic stock.

5.3.5.2. Implementation

A fire regime requires the parallel implementation of a stocking strategy that allows for fuel build up before burning and pasture recovery afterwards. It may be facilitated if contiguous areas requiring similar fire regimes are fenced together. A minimum pasture yield for a fire that will be useful in controlling woody plants is around 2,000 kg/ha. The intensity of a fire will be affected by the amount of fuel available but also by weather conditions and the state of the fuel at the time of burning. Fuel moisture (for example <35%), high atmospheric temperatures, low relative humidity and high wind speeds will lead to higher intensity fires. Lower intensity, or just slower moving fires, with long residence times may actually lead to higher mortality rates of some trees and shrubs.

5.3.5.3. Considerations/caveats

Matching stocking rates to long-term carrying capacities increases the prospects for incorporating fire into a management system. Consideration must be given to whether fire is the most appropriate tool for a particular location or system. If the main purpose of burning is to manage woody plants, the costs and benefits of fire must be weighed against those of mechanical and chemical methods of tree and shrub control. It is important to burn when conditions are suitable which will mean waiting for the appropriate season, probably reducing the costs of burning in terms of lost animal production.

5.3.6 Management action: implement pasture spelling

Pasture spelling is a means of managing both fuel build up and post-fire recovery. Spelling a pasture during all or part of the growing season prior to burning would facilitate the accumulation of grass fuel. This is one way of increasing the likelihood of being able to conduct an effective fire for woody plant management. A spell during the post fire period should be designed to allow palatable perennial grass tussocks to recover from having been burnt and, ideally, to set seed.

5.3.6.1 Evidence

Grazing studies conducted in both the Burdekin catchment and the VRD provide evidence for the effect of pre- and post-fire spelling on herbaceous biomass (McIvor, 2010).

5.3.6.2 Implementation

The length of a pre-fire spell period necessary to facilitate fuel accumulation depends on soil moisture levels which are dependent on rainfall received. In poorer growing seasons and in lower rainfall zones a longer period of spelling would be required in order for a particular threshold of herbaceous biomass to be reached. Thus there will be great temporal and spatial variation in what constitutes appropriate pre-fire and post-fire spell periods. In highly favourable seasons it will be possible to conduct an effective prescribed fire without a pre-fire spell period as herbaceous production will exceed off-take by livestock.

5.3.6.3 Considerations/caveats

See comments under 3.5.3.

5.4 Ungrazed areas distant from water

In large paddocks considerable areas of ungrazed palatable forage often occur. In the Fitzroy suboptimal paddock and water design is probably the main contributor to unused pasture. This unused pasture represents livestock production that is forgone by the pastoral business whilst areas near water often become degraded through overgrazing. 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. However, paddock areas that are remote from waters often leads to a biodiversity benefit. For example, silver-leaved ironbark country often has a greater abundance of kangaroo grass in water remote areas

Developing the water point and fencing infrastructure on a property to improve grazing distribution is the primary management option to address this issue although 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.

5.4.1 Signs

In large paddocks—or paddocks with suboptimal paddock and water design—significant areas of the paddock 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.

5.4.2 Causes

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. If there are more than 300 head per water point this can result in high grazing pressures around watering points. Additionally paddocks containing more than one land type may be preferentially grazed, particularly if there is a nearby water point.

5.4.3 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.

5.4.4 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 exceed about 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 have at least one water point per 2000–2500 ha of land area. More realistically, aim for paddocks no larger than 1000 – 1500 ha with two water points. Water points should be well separated and away from fences with no more than 300 head per water point.

5.4.4.1 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 US 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 three 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 only about 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 (McIvor, 2010) 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 (McIvor, 2010) 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 approximately 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.

Although the evidence from research is minimal, and there is often considerable variation in cattle grazing behaviour, we are reasonably confident with the recommendation to establish water points in paddocks so that most of a paddock is within 3 km of water in order to minimise the amount of forage that is inaccessible to cattle.

5.4.4.2 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 and loiter 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 soils that are highly erodible. 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.

5.4.4.3 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.

Obviously 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.

It is also important to note that despite having improved access to water, cattle will continue to graze paddocks unevenly to some extent. Other techniques to attract cattle to under-utilised areas should also be implemented. For example, the strategic location and regular relocation of supplements, and strategically burning 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 spelled from grazing for an entire growing season before being grazed again (see sections 5.3, 5.5.3 and 5.5.6). 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 potentially kill the regrowing perennial grasses (see section 5.5.7).

Spelling may also be required to allow the recovery of overgrazed areas once new water points are established (see sections 5.3, 5.5.3 and 5.5.6).

The effect of installing additional waters on the natural biodiversity of an area should also be considered. Many grazing-sensitive species of native fauna and flora now only exist in areas that are remote from water. 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 recommendation is that up to 10% of a property should be set aside to protect biodiversity.

5.4.5 Management Action: reduce 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, because the financial cost involved can be substantial, it might be considered to be less attractive than establishing additional water points.

5.4.5.1 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, some areas in large paddocks may still not be grazed much because the 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 (McIvor, 2010) 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. 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) 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.

However, there will be 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 two km from water. 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 might be appropriate for this region (although there are no readily available data on grazing patterns for larger paddocks in this region).

5.4.5.2 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) 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 one water point per 2000–2500 ha of land area is the minimum to ensure all areas are accessible to cattle.

Consultations with industry and technical experts recommend that paddocks should be no larger than 1000–1500 ha, with two water points.

5.4.5.3 Considerations/caveats

Cost is a major consideration when reducing paddock size. Fencing costs escalate rapidly for paddocks smaller than about 3000 ha 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.

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.

As mentioned earlier, 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. The rate at which overgrazed areas grow will be slower. As well as reducing paddock size, the use of other tools such as the strategic placement of supplements or prescribed fire should also be considered to improve grazing distribution in paddocks (see section 5.4.3).

6. Conclusions

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

- Optimising animal productivity; and
- Keeping the land healthy, productive and sustainable

The key principles:

- Stock to carrying capacity for that land type, region and land condition
- Factor in spelling to allow for pasture recovery, seed set and land condition maintenance or improvement
- Manage encroachment of weeds, in particular woody weeds
- Use strategies to even up pasture utilisation (fire, strategic placement of waters, fences and supplements).

Management strategies that address any or all of these key principles will be helping to improve land condition as well as providing the basis for a more profitable and sustainable beef business.

7. Contributing to the best-bet practices for managing the grazing lands of the Fitzroy woodlands a technical guide

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 1206 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 filling in the form below and returning to DEEDI Roma (PO Box 308 Roma, QLD, 4455).

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. 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 issues associated.

8. Contributions to NGS technical guide form

Name____

Company____

Contact details

E-mail____

Phone____

Fax____

Date____

Issue this information is related to:

____

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Details (please include reference, contacts or page numbers where appropriate):

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Other general comments:____

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(Please attach additional pages if needed)

9. Glossary of terms

Adult equivalent
A system that allows livestock of different age, weight and metabolic state to be compared equally according to their relative intakes.

Growing season
Most grass growing rain falls from November through to March in the Fitzroy woodlands. During this period, energy from daylength, temperatures and radiation drive photosynthesis for prolific 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. 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.

Pasture growth model
A computer program that estimates pasture growth by simulating ecological processes with mathematical relationships

Stocking rate
The number of stock in AEs per unit area at a particular time – usually ha per animal.

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.

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.

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