BEST-BET PRACTICES FOR MANAGING GRAZING LANDS IN THE ALICE SPRINGS REGION OF THE NORTHERN TERRITORY

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

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1 INTRODUCTION

This technical guide has been written to help inform and improve grazing management in the Alice Springs region. It focuses on five major themes: managing stocking rates, spelling pastures, pasture restoration, prescribed burning and property infrastructure development. The guide is intended as a technical resource for those working with producers to improve the management of grazing lands.

The guide is a product of the Northern Grazing Systems (NGS) initiative which was developed and implemented in a partnership between Meat and Livestock Australia (MLA), CSIRO, the Northern Territory (NT) Department of Resources (now the Department of Primary Industry and Fisheries (DPIF)), the Queensland (Qld) Department of Employment, Economic Development and Innovation (DEEDI) and the Western Australia (WA) Department of Agriculture and Food. This initiative was designed to ensure that the beef cattle industry in the NT, Qld and northern WA derives the full benefit from research on how best to manage grazing country for beef production.

The information in this guide 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 the region.

Future work in the region will focus on working with producers and their advisors to increase awareness, understanding and uptake of improved grazing practices. The technical guide will be a key reference for extension activities and will continue to be improved by new 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 publications from completed research on grazing land management relevant to northern Australia (Qld, the NT and the northern rangelands of WA). This review focused on four themes: managing stocking rates, pasture spelling, prescribed burning and intensifying property infrastructure with more fences and water points (see McIvor et al. 2010). For the Alice Springs region, workshop participants felt that a decline in landscape function and subsequent soil loss is a significant driver of land condition, animal production and economic performance for the pastoral industry in the district (White and Walsh 2010). The issue of pasture restoration was therefore added as a fifth theme for this technical guide.

2. Outputs from testing different management options through computer simulation models. The effects of stocking rates, pasture spelling and prescribed burning 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 where climate data exists. The pasture and animal productivity output from GRASP was subsequently used in an economics spreadsheet model called ENTERPRISE to assess how various management practices 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 provided a way of extrapolating responses to grazing management measured in grazing trials to a wider range of land types and climate conditions. It also provided a way to test many variations in grazing management that would be expensive and time-consuming to test on the ground. This helped to identify the practices that have the most impact and narrowed down the most cost-effective ways of implementing these practices (see Scanlan 2010).

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 during two workshops and by direct input to reports, including this guide. This local input also identified and prioritised research gaps in the region.

Not all practices (or the many variations of these practices) have been objectively evaluated in every region of northern Australia. 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 modelling have therefore been very important in helping form the guidelines and ideas in this 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 USE OF THE TECHNICAL GUIDE

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

- How to best manage stocking rates over time to keep pastures in good condition and optimise beef production (Section 5.2).
- How to most cost-effectively recover pasture that has declined to poor (or 'C') condition (Section 5.3).
- How to rehabilitate landscapes where grazing management changes alone will not restore productivity (Section 5.4).
- How to manage woody vegetation thickening (Section 5.5).
- How to most cost-effectively bring under-utilised pastures into production (Section 5.6).

For each issue, information is presented on:

- Signs (what the issue looks like on the ground).
- Underlying causes.
- Management responses – the key practices and their rationale.
- The specific management actions that can contribute to achieving better practice and the evidence-base for them.
- How to implement these actions.
- Trade-offs, caveats and uncertainties.

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

The guide can be used in several ways:

- For people working with producers, as:
    - a means of improving their understanding of key grazing management practices and their awareness of the evidence base that underpins these practices
    - a source of ideas for management strategies that will most cost-effectively address a particular issue or objective
    - a guide to which issues/practices and variations of these deserve additional extension activity through demonstration sites or other processes

  - a guide to which issues/practices and variations of these require more research and/or on-property testing.
- As a source of new information and examples for extension activities and information products, including Grazing Land Management (GLM) workshop materials.
- As a means of capturing new insights and information from interactions with producers, property case studies and demonstrations.
- As a framework for capturing the results of future research trials and modelling.

4 THE ALICE SPRINGS DISTRICT

The Alice Springs pastoral district encompasses a large area in the southern part of the NT. It extends from approximately Barrow Creek in the north to the South Australian border and spans three quarters of the width of the NT. Rainfall can occur at any time of the year in the south-east of the region but becomes more summer-dominant towards the north-west (Thackway and Cresswell 1995). Summer rain (October to March) is largely a result of moist oceanic air from the equatorial regions; winter rain (April to September) is usually a result of depressions that cross from west to east to the south of the continent (Foran 1984). Rainfall in Central Australia is very unpredictable in location and time (Stafford Smith and Morton 1990) and median figures are more useful than averages for describing rainfall as they help remove the distorting influence of very wet years (Chilcott et al. 2005). Rainfall tends to be higher in the north (Barrow Creek has a long-term annual median of 281 mm) and very low in the south (Mt Cavenagh Station has a median of 167 mm) while Alice Springs has a median of 237 mm (www.bom.gov.au). Effective rainfall for pasture growth is also lower than the annual figures might suggest because rain often occurs in small, individual events with low totals that are insufficient to achieve maximum pasture growth (Stafford Smith and Morton 1990). In Central Australia, growth events are defined as approximately 50 to 58 mm of rain with positive soil moisture levels maintained for about four weeks (Slatyer 1962; Pickup and Stafford Smith 1993). Typically, there will be only two growth events expected in an average year in the northern Alice Springs region and half, to one and a half, growth events per year in the southern Alice Springs region (Slatyer 1962).

The temperature regime for the Alice Springs region is characterised by large seasonal and diurnal variations (Foran 1984). For Alice Springs, maximum daily temperatures in July average 19.7 ºC with frosts occurring on 13.8 days on average. Winter temperatures tend to be slightly higher in the northern parts of the region. Average daily maximum temperatures at Alice Springs in January are 36 ºC with temperatures of 40 ºC not uncommon. There appears to be a warming trend in the region, with mean annual minimum and maximum temperatures increasing by about 1 ºC since 1980 (Bureau of Meteorology, http://www.bom.gov.au/cgi-bin/climate/hqsites/site_data.cgi?variable=maxT&area=aus&station=015590&dtype=anom&period=annual&ave_yr=5).

The Alice Springs region contains a wide variety of landscapes with a broad range of production values. Low pastoral productivity spinifex sand plains and dune-fields are the most dominant landscape in the region. Open woodlands are the most common moderate to high productivity pasture type. Other useful pasture types include alluvial plains with perennial grasses, calcareous shrubby grasslands, gidyea woodlands with perennial grasses, Mitchell grass plains and mulga with annual grass pastures. The sandy open woodlands and open gidyea woodlands have moderate pastoral productivity while mulga woodlands with less palatable perennial grasses have only low pastoral value (Chilcott et al. 2005).

During the consultative workshops, participants indicated that there was sufficient difference in the landscapes, management practices and livestock markets of the northern and the southern parts of the Alice Springs region to warrant separate consideration. Participants described an average property in the northern Alice Springs region and this information was used as the basis for the model simulations reported in this guide and elsewhere (White and Walsh 2010).

Northern Alice Springs properties are typically breeder operations producing store cattle (typically 18-month old steers). Herd sizes are approximately 3000 head of which approximately 70% are breeders (White and Walsh 2010). Because of its location, the region can target both the live cattle export and domestic markets.

The average property size in the northern Alice Springs region is about 3400 km^2. Properties typically have relatively large paddocks, ranging in size from 100 to 800 km^2, with most paddocks having two or more land types. The average number of paddocks per property is about 14 (White and Walsh 2010). The average number of man-made water points per property is about 27 (Leigo 2004) while the average maximum distance from water is 10 km. Water point development is a high priority for many producers; however, costs and the difficulty to find water are constraining the rate of development (White and Walsh 2010).

Opportunistic pasture spelling and continuous grazing are the most common grazing strategies used in the Alice Springs region (Leigo 2004; White and Walsh 2010). The typical approach to managing stocking rates is through trial and error, and experience rather than formal assessments of carrying capacity or forage budgeting (Leigo 2004).

Most producers in the region aim to suppress fire rather than undertake prescribed burning (Edwards et al. 2008; White and Walsh 2010). When fire is used, the reasons are predominantly to prevent wildfire, improve palatability of spinifex country and control woody vegetation thickening (O'Reilly 2001a; Leigo 2004; G. Allan pers. comm. November 2011). Woody vegetation thickening is an issue for many producers in the region, with the main impacts being damage to infrastructure (such as fence-line encroachment) and increased mustering costs (Leigo 2004).

5 GUIDELINES FOR GRAZING MANAGEMENT, PASTURE RESTORATION AND PRESCRIBED BURNING

5.1 INTRODUCTION

The following sections specifically address five key issues facing grazing land managers in the region, with information structured so that it targets the specific characteristics and causes of each issue. The key issues, and their signs and causes, are summarised in Table 1. Figure 1 shows how the information related to these issues is structured in each section of the guide.

Table 1. Key grazing land management issues for the Alice Springs region

Issue	Sign(s)	Underlying cause(s)
1. The challenge of matching animal demand to pasture supply on land in generally good land condition	• Pastures are mainly in good (A or B* condition. • Such pastures will change in appearance depending on seasons, with ample feed for the whole year in above-average rainfall years, adequate feed for the whole year in average seasons and possible feed shortages in below-average rainfall years. • There may be a few overgrazed patches with low ground cover and less desirable species (C condition).	• Spatial and temporal variability in pasture growth between years, during years and on different parts of the property. • Cattle grazing preferences. • Limited flexibility to vary cattle numbers within and between years, especially for breeder enterprises.
2. Managing pastures in poor (C) land condition	• Most of the paddock or preferred land type(s) are in C condition. • There are still some preferred perennial grasses but they are small, widely spaced and have low vigour. • Persistent patch grazing is occurring. • Ground cover is generally poor with some erosion and significant loss of moisture through run-off. • In some cases there is a high proportion of undesirable species, such as unpalatable grasses and forbs. • Highly nutritious feed may be available for short periods but feed shortages can develop quickly during dry periods.	• Chronic overgrazing of paddocks. • Selective use of land type or area of the paddock. • Exacerbated by drought and/or intense/frequent wildfire events.
3. Rehabilitating pastures in D land condition	• General pasture cover is very low. • Water either runs off or is diverted away from the landscape. • Palatable, productive grasses are absent or very rare. • Severe erosion, such as gullies, sheet wash and scalding, is present. • General disruption of the natural drainage patterns has occurred. • Woody vegetation thickening.	• Disruption of run-on and run-off processes due to poor infrastructure development and/or overgrazing. • Incision of landscape base levels so that water is no longer retained in a particular area. • Loss of topsoil and seed banks. • Drying-out of the soil reduces pasture growth and therefore gives a competitive advantage to deep-rooted woody species.
4. Managing woody vegetation thickening	• Increased density of shrubs and trees, particularly on productive soil types. • Reduced pasture growth when woody vegetation is dense.	• Sequences of very wet years. • Reduced competition from grasses due to heavy grazing. • Reduced frequency and/or intensity of effective fires. • Fire-induced germination events. • Disruption of natural drainage patterns and hydrology.
5. Bringing under-utilised pastures into production	• Significant areas of the paddock receive little or no grazing pressure. • Old, rank pasture with limited vigour, even after rain.	• Inadequate number and/or location of water points in relation to paddock size. • The distance of pasture from water is too great for cattle to access it. • Sometimes strong avoidance of particular areas (e.g. poor water quality).

*Land condition conventions follow Chilcott et al. (2005) where A=good, B=fair, C=poor and D=degraded

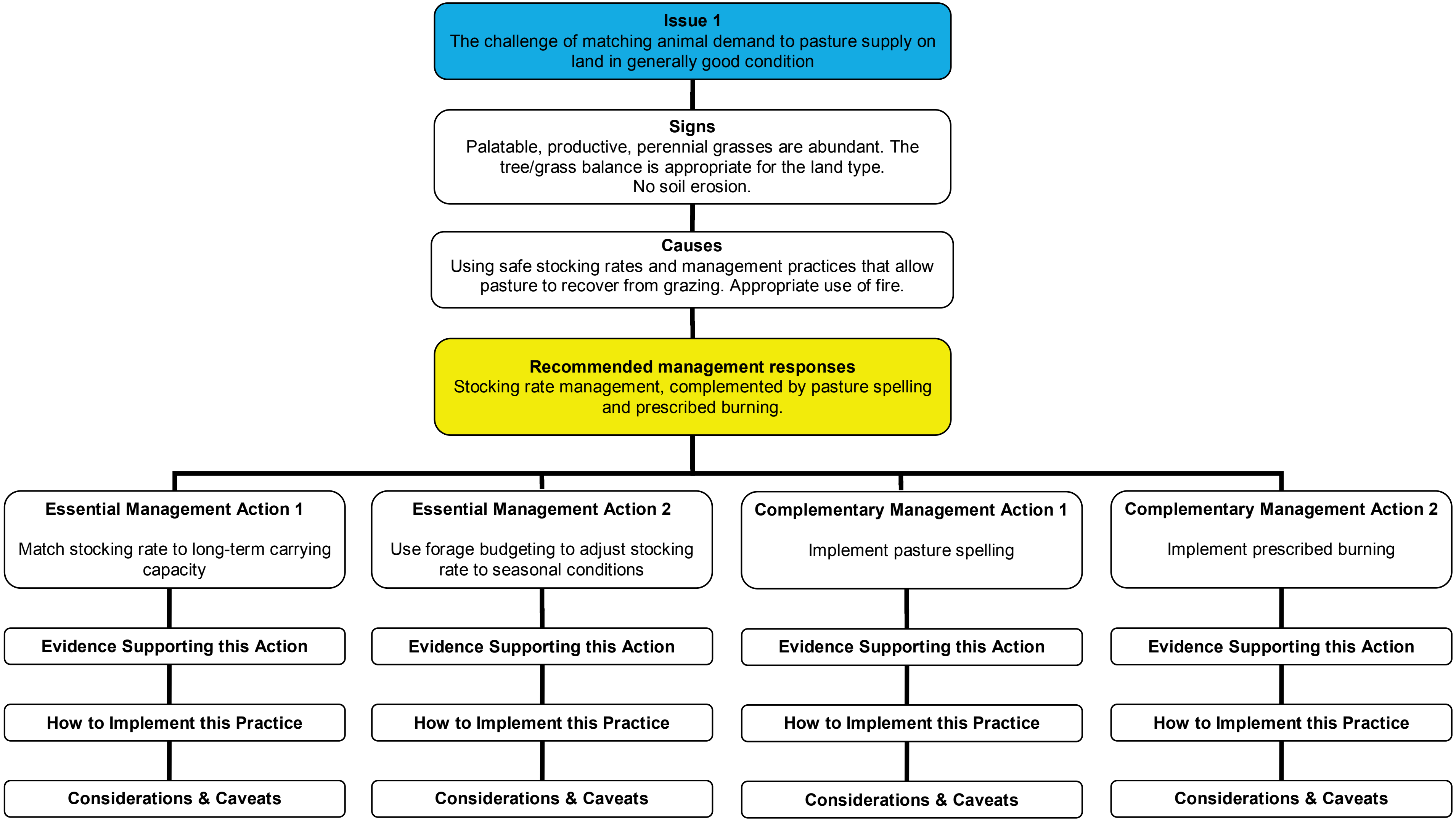


Figure 1. Diagrammatic representation of how this technical guide is structured, using "The challenge of matching animal demand to pasture supply on land in generally good condition" as an example issue

5.2 ISSUE 1: THE CHALLENGE OF MATCHING ANIMAL DEMAND TO PASTURE SUPPLY ON LAND IN GENERALLY GOOD CONDITION

This section of the guide provides information on how to maintain land in good condition. Other sections describe practices to improve land in poor condition.

Relatively small areas (~ 20%) of Central Australia are considered to be in good land condition (Pastoral Land Board 2010a, 2010b). The amount of feed grown each year varies widely due to the timing and amount of rainfall, so the appropriate number of animals to utilise the feed also varies widely. In above-average rainfall years, high stocking rates can increase animal production per hectare; however, in below-average rainfall years, high stocking rates result in poor animal production outcomes and degraded pastures. A major challenge facing producers is thus how to optimally use feed for animal production while maintaining good land condition.

In theory, it is possible 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. Conversely, animal numbers and production can be sustainably increased in years with high pasture growth. However, matching demand to supply is not easy to do because the feed supply is not known in advance, and there are practical limitations to how much and how often animal numbers can be altered, particularly for breeding enterprises. In variable and unpredictable climates, it is also useful to have a reserve or carry-over of fodder to buffer against a lack of growth in subsequent years (Christie c. 1980; Pickup 1995).

In Central Australia, highly variable and unpredictable seasons are the norm. Above-average rainfall years can be immediately followed by extended dry periods. If land is in good condition, it can respond quickly to rainfall, and the resultant pasture growth is often more robust and able to persist well into dry periods (Reu 2000; Chilcott et al. 2005). A more resilient feed base, in conjunction with good breeder herd management, helps to stabilise income. A stable income is generally seen as an important factor for long-term enterprise profitability in a variable and unpredictable climate (Bastin 1991a; Foran and Stafford Smith 1991; Bastin et al. 2001).

Matching animal demand to pasture supply also ensures that cattle have access to the best possible nutrition at any given time. For breeders, this helps to minimise mortality rates and ensures appropriate body condition to maximise conception rates and pregnancy success (Schatz et al. 2008). Poor breeder productivity and high mortality are major contributors to poor profitability in the northern beef industry (McCosker et al. 2010).

5.2.1 Signs

Land in A or B condition (Chilcott et al. 2005) indicates that the pastures have not been overgrazed in the past, or if some overgrazing has occurred, the pastures have been allowed to recover. Such pastures will change in appearance depending on seasons (i.e. the dominant species may vary slightly or the amount of biomass may change). In very low rainfall years, useful pasture may not grow at all; but the land is still considered to be in good condition if it retains the *potential* to grow useful pasture. Indicators of this potential include the presence of perennial grass butts, intact topsoil and stable ground cover.

Even in pastures that are predominantly in A or B condition, there may be some overgrazed patches with low ground cover and the presence of less desirable species (C condition). It is the continued overgrazing of these C condition patches that leads to them increasing in size and frequency. If this overgrazing is continued over a period of years or during dry periods, the average land condition can move from A/B to C.

5.2.2 Causes

By definition, producers with large areas of pastures in A/B condition successfully match supply and demand most of the time. The major cause of mismatches in feed supply and demand for these producers is the temporal variability in pasture growth. Pasture growth can vary widely between years, during years and on different parts of the property. This is compounded by the production system of extensive beef enterprises in which most animals tend to stay on the property for more than one year and, in the case of breeders, up to 10 to 12 years. Changing cattle numbers within or between years will have immediate and ongoing impacts on herd structure and cash flow, as well as exposing the business to risks in the market (which also varies within and between years). Hence, many rangeland beef enterprises have limited flexibility to vary cattle numbers within and between years and breeder enterprises have the least flexibility of all.

However, this is not to say that cattle numbers stay fixed. In any given year, variation in numbers, particularly adult equivalents (AEs), occurs by selling animals such as steers, surplus heifers and cull cows, producing calves, buying animals such as bulls and from changes in live-weight and/or physiological status of individual animals. On a typical breeder property, these factors may result in a variation in AEs in the order of 10% to 20% a year (McIvor et al. 2010). The total AEs will also vary between years due to variations in breeding, mortality, retention and selling rates, and the timing of sales. For example, delaying the sale of steers and cull heifers by just two or three months can increase the average AEs carried in a year by 10%.

Given the variability in pasture supply through time and the limited capacity to adjust cattle numbers, the management questions that arise for pastures in A/B land condition include:

a. What combinations of stocking rate and pasture spelling will deliver the best animal production, economic and land condition outcomes?

b. What are the best options for managing stocking rate to reduce the risk of overgrazing in below-average rainfall years?

c. How do I best take advantage of the extra feed in above-average rainfall years?

5.2.3 Management responses: stocking rate management, complemented by pasture spelling and the use of prescribed burning

Although changes in growing conditions are a major cause of mismatches between feed supply and demand, they are largely outside the control of producers. The most effective management response is thus to adjust stocking rate (the demand side of the equation). Pastures can also benefit from complementary practices, such as pasture spelling and/or prescribed burning. Spelling can be used to increase the quantity of the pasture supply and/or alter when it is consumed. Prescribed burning can be used to modify animal behaviour and eliminate the contrast in pasture growth caused by patch grazing. Burning can also improve the overall availability and quality of feed by reducing competition with woody plants and removing old, rank growth (e.g. in spinifex country). The following pages explain in detail how these practices can be used to match animal demand to pasture supply on land in good condition.

5.2.4 Essential management action 1: match stocking rate to long-term carrying capacity

There are three broad approaches to the management of stocking rate. The first approach is to stock at a relatively low level year-in, year-out so that the level of pasture utilisation is not excessive in any given year (or at least in most years). This approach avoids overgrazing in below-average years but forgoes the extra animal production that could be achieved in above-average years and hence may incur a financial penalty. However, research has shown that this approach avoids losses in below-average years and can lead to enhanced financial performance over the long-term (Buxton and Stafford Smith 1996; O'Reagain et al. 2009, 2011). When forage growth exceeds demand, it provides a buffer against subsequent poor growth periods, allowing cattle numbers to remain more constant in the medium term. It also allows perennial species to regenerate and become well established, increases ground cover and can also provide producers with opportunities for prescribed burning.

The second approach is to adjust animal numbers seasonally so that animal demand closely matches current and/or anticipated feed supply (i.e. a trading approach). This practice should theoretically minimise periods of overgrazing and feed deficit while making good use of feed in above-average years. Although this approach can minimise pasture "going to waste", there is a risk of overgrazing if animal numbers are not reduced quickly when the pasture supply is declining. If left too late, there is a risk of being caught with excess animals and insufficient feed, leading to forced sales (perhaps at a loss), loss of animal condition, production penalties, additional feed costs, increased mortalities and/or land degradation (O'Reagain et al. 2011).

The third approach is to also adjust stock numbers in response to feed supply, but in a way that maintains stocking rates close to the long-term recommended average most of the time. In contrast to the approach described above (where action to reduce high stock numbers needs to be done promptly to avoid feed shortages), a moderately stocked property can often afford to take a "wait and see" approach before decisions become critical.

Risk-averse approaches to stocking rate management have generally proven to be the most successful for optimising land condition and profitability in the rangelands. Stocking at close 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 (Buxton and Stafford Smith 1996; Landsberg et al. 1998; O'Reagain et al. 2009, 2011).

Whilst stocking rates in excess of the long-term carrying capacity can be very profitable in the short term, they are less profitable over the longer term because of the effect of poor pasture growth years and subsequent declines in land condition, and pasture productivity. Maintaining high stocking rates during poor growth years is the primary cause of land degradation and can reduce production for several years or increase variability in production. High stocking rates (especially on poor condition land or in below-average seasons) result in weight-for-age penalties at market and/or increased supplement costs, both of which can reduce profit (O'Reagain et al. 2009, 2011).

There is a perception in the northern beef industry that "more cattle" equals "more animal production" and that stocking at close to the long-term carrying capacity is not economically viable. However, using stocking rates in line with recommended carrying capacities does not necessarily equate to lower overall herd production. In fact, in conjunction with high quality stock, the opposite is often the case. When stocking rates are sustainable, animals have more opportunity to selectively graze and achieve optimum nutrition. The subsequent live-weight gain and body condition score benefits can lead to increased production per head. For example, a breeder in good body condition has a much higher chance of re-conceiving, and weaners can reach target weights faster (Schatz et al. 2008). Stocking at close to the long-term carrying capacity provides the best option for successfully balancing pasture productivity, good land condition and profitability for most enterprises in the rangelands.

The long-term carrying capacity of paddocks and properties can be determined using safe pasture utilisation rates and historical pasture growth data for each land type. Walsh and Cowley (2011) used cattle records and modelled pasture growth from commercial paddocks in good land condition to retrospectively calculate safe pasture utilisation rates in the NT. The assumption for this technique was that commercial paddocks in good land condition have been well managed and the computed long-term average pasture utilisation rate can thus be considered 'safe' for that land type. The long-term sustainable utilisation rates recommended in the Alice Springs region are currently 20% for the most productive land types, 15% on woodlands and mulga, 10% on calcareous landscapes and 5% on spinifex. Grazing studies in Qld and higher rainfall areas of the NT show that declines in pasture condition occur when high utilisation rates (>30%) coincide with average to below-average rainfall seasons. Several studies investigating long-term pasture change in Central Australia have identified a combination of heavy grazing and drought years as being the key precursors of declines in soil stability and pasture productivity (Chippendale 1963; Friedel 1993; Kinloch and Friedel 2005a, 2005b).

In regions where rainfall is relatively predictable, the safe pasture utilisation rate for a given land type is typically applied to the pasture growth that would be expected in at least 50% of years (i.e. the long-term median growth). This approach implies that animal demand will exceed pasture supply half the time; however, in more reliable rainfall zones, below-average years do not tend to occur over many successive years and so any loss in land condition may be readily restored in subsequent above-average seasons. However, when this approach is applied in less productive regions and where rainfall is more variable and unpredictable (e.g. Central Australia), there is a higher risk that overgrazing will occur for several consecutive years. Applying the safe utilisation rate to the annual pasture growth expected in at least 70% of years helps reduce the potential impact of overgrazing during extended periods of below-average rainfall (Scanlan et al. 1994; Ash and Stafford Smith 1996; O'Reagain et al. 2009, 2011). This approach is also recommended for more risk-averse producers (Chilcott et al. 2005) and would be useful in situations where it is desirable to retain stable stock numbers because it is based on a level of pasture growth that is likely to occur more often (≥70% of years).

Using the GRASP pasture growth model, it is possible to assess the impact of a range of fixed continuous stocking rates on land condition over long periods of time. The model simulates a decline in land condition when the recommended safe utilisation rate is exceeded and an improvement in land condition when predicted pasture utilisation is less than the recommended safe rate. The stocking rate that maintains land condition over long periods in GRASP can thus be considered the safe stocking rate. Using this approach for an open woodland land type in A condition in Central Australia, the recommended safe stocking rate predicted by GRASP (1.9 AE/km^2) was higher than that calculated using the recommended utilisation rate of 15% on pasture growth that could be expected in 70% of years (1.4 AE/km^2) (Walsh and Cowley 2011; R. Cowley, pers. comm., 30 November 2011). In contrast, if the 15% utilisation rate was applied to the long-term *median* pasture growth figure, the recommended stocking rate was much higher (2.4 AE/km^2) than the safe stocking rate that maintained good land condition. Indeed the model output suggests that fixed stocking rates this high would have caused a collapse to C land condition over the 30-year period from 1981 to 2010 (Figure 2).

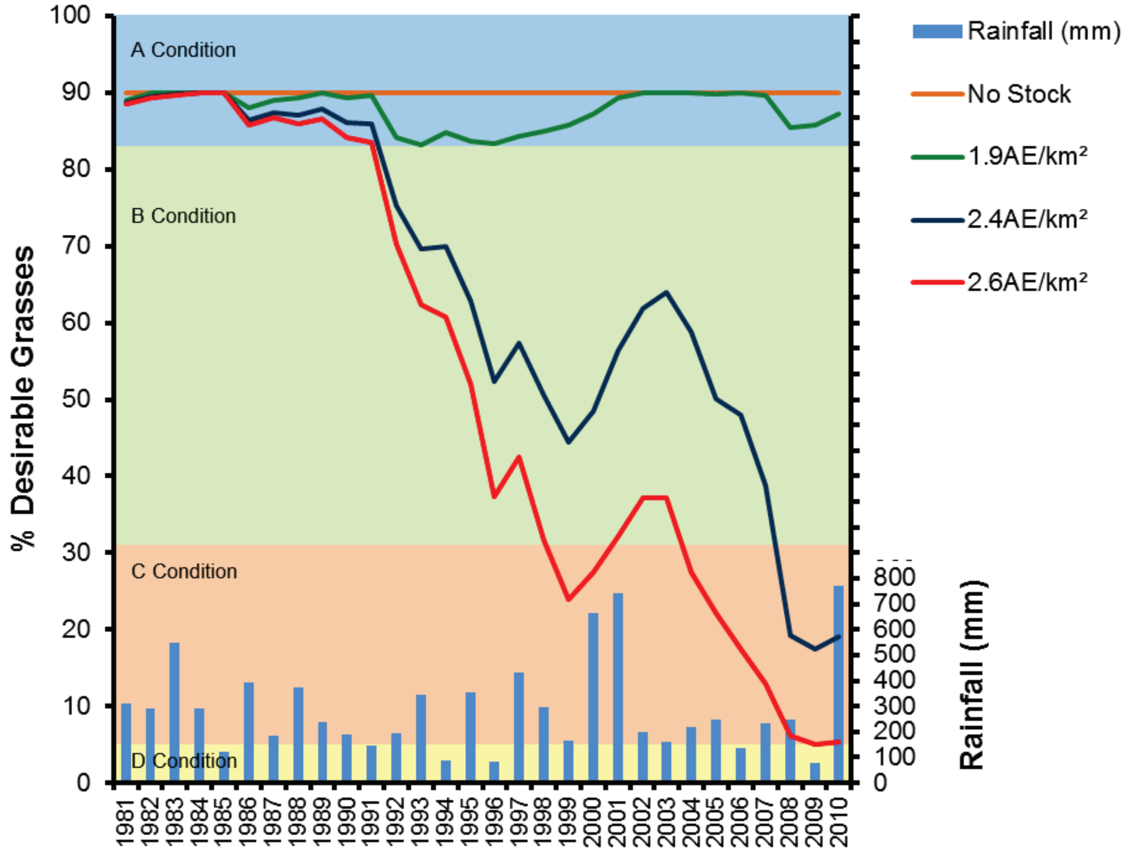


Figure 2. GRASP simulation of the impact of stocking rates on land condition for an open woodland land type in the Alice Springs region starting in A condition (1981-2010). Percentages desirable species are used as a proxy for land condition (A ≥84%, B=32-83%, C=6-31%, D≤5%). This simulation suggests that 1.9 AE/km^2 is a safe stocking rate for this land type in A condition as it does not cause land condition decline. When the recommended pasture utilisation rate of 15% is applied to long-term median growth (resulting in a stocking rate of 2.4 AE/km^2) land condition steadily declines to C condition. Note that the rainfall shown is from 1 January to 31 December each year whereas the model output year is 1 May to 30 April.

5.2.4.1 Evidence supporting this management action

Long-term carrying capacity in Central Australia is relatively low and local case studies have highlighted some successful Central Australian grazing enterprises that use conservative stocking rates. Producers in these case studies noted several benefits of running sustainable stocking rates, including increased animal production, stability of production and income, maintained or improved land condition and better drought management (Walsh 2009d, 2009e). One case study property, operating with a constant sustainable stocking rate, turns off finished cattle every year from Central Australia regardless of seasonal conditions.

There is little published research regarding long-term carrying capacity in Central Australia, primarily because of the difficulty in undertaking research that covers the full range of climatic conditions and land types. It is possible to draw some insights from an understanding of the environment and how it interacts with grazing. Using stocking rates that are close to the long-term carrying capacity allows fodder to accumulate in high rainfall years. In a variable climate, this extra fodder can provide a buffer in a subsequent dry period. A reserve of fodder also buffers against some errors in estimations of pasture growth and stocking pressure (Ash and Stafford Smith 1996). It has been noted that running highly variable stock numbers requires a ‘reserve of capital’ in order to survive dry periods whereas running low, constant stock numbers requires a ‘reserve of fodder’ (Pickup 1995).

In a model analysis of high, average and low stocking rates using the RANGEPACK Herd-Econ spreadsheet, Foran and Stafford Smith (1991) found that properties with low stocking rates performed better after four years of drought compared with properties with average or high stocking rates. This was largely attributed to comparably higher returns during the drought years, and high and resilient rates of reproduction and live-weight gain. Heavily-stocked operations that reduced numbers quickly performed better than average-stocked properties, although the risk of causing environmental damage was much higher. Average-stocked properties tended to have a greater risk because of the “wait and see” attitude made possible by the herd size. Rather than making a general recommendation on drought strategy, Foran and Stafford Smith (1991) highlighted the benefits of modelling to determine the best outcome for individual enterprises.

The importance of matching stocking rate to the long-term carrying capacity and adjusting stocking rates from year to year is highlighted in bio-economic model simulations conducted for Central Australia. The most common strategy used by producers in Central Australia is relatively modest variation in stock numbers from year to year (White and Walsh 2010). The performance of this strategy was simulated using the GRASP pasture growth model and the ENTERPRISE economic model as follows (Scanlan et al. 2011). If current stocking rates were above the safe stocking rate, GRASP allowed annual stocking rate increases of up to 10% if pasture growth was sufficient to allow this and annual decreases of up to 25% if pasture growth was inadequate to carry the current stock numbers. If stocking rates were below the long-term safe stocking rate, GRASP allowed annual increases of up to 20% when pasture growth was sufficient and annual decreases of up to 30% if pasture growth was insufficient to carry the current numbers. To reflect common practice in the district, long-term (i.e. over a 30-year period) variation in stock numbers was capped at a modest 30% increase and a 50% decrease compared with the long-term average. Model simulations between 1981 and 2010 indicated that the typical industry strategy resulted in the best average pasture growth, land condition and live-weight gain per head, but only when used in conjunction with long-term safe stocking rates (Table 2). With higher (current typical industry practice) stocking rates, profitability was lowest and caused a crash in land condition. The starting stocking rate for the “higher stocking rate” strategy was 2.3 AE/km^2. Because this was generally too high for the available forage (the model aims to utilise only a safe level of the available total standing dry matter), the model started to adjust the stocking rate downwards immediately. The current flexibility strategy only allowed adjustment of stocking rate down by 50% to 1.2 AE/km^2. Even though the stocking rate was maintained at the minimum possible for most of the simulation, it was still too high to maintain land condition. The current flexibility strategy with a high stocking rate was unsuccessful because the limits prevented the model from reducing stock numbers enough in average and poor seasons.

Table 2. Average property outcomes for different stocking rate flexibilities at Alice Springs (strategies are described in the text above). The average is of all land types and years (1981 to 2010). Most paddocks started in C condition but some started in B condition. The starting stocking rate was 1 AE/km^2 for all strategies except the "Current Flexibility with Higher Stocking Rates" which started at 2.3 AE/km^2. Land condition improvement was averaged over the whole property. Average % desirable grasses is used as an indicator of land condition (A condition ≥84%, B=32-83%, C=6-31%, D≤5%). LWG=live- weight gain. NA indicates land condition never recovered to that value.

	Stocking rate flexibility strategy				
Performance indicators	**Fixed (set stocked)**	**Current (modest) flexibility**	**Current (modest) flexibility with higher stocking rates)**	**Moderate flexibility**	**Full flexibility**
Average stocking rate achieved (AE/km²)	1.0	0.9	1.3	1.0	1.9
Average annual profit	$118 806	$194 669	$53 061	$172 644	$354 230
Number of negative profit years	8	6	18	12	15
Average LWG/ha	0.5	1.1	0.1	1.1	2.5
Average LWG/head	70	129	41	107	83
Average annual pasture growth (kg/ha)	319	595	254	503	405
Average % desirable grasses	29	87	7	85	61
Avg. no. of years to reach A condition	NA	21	NA	22	NA
Avg. no. of years to reach B condition	NA	3	NA	3	17

Impact of stocking rate management on land condition

It is important to note that regardless of the degree of flexibility being applied, stocking rates must be appropriately matched to the long-term carrying capacity to optimise land condition and animal production outcomes. Model simulations of the current industry practice of "modest flexibility with higher stocking rates" resulted in a gradual decline in land condition for open woodland starting in B condition (Figure 3). This trend was the same for other land types modelled and is supported by a local study of vegetation change, which found that the proportional cover of palatable species declined with increased grazing on oatgrass country (Friedel et al. 2003). When the current degree of flexibility was modelled using recommended stocking rates, good land condition was maintained for the duration of the simulation.

In the medium to long-term (>10 years), sustained high stocking rates lead to land degradation, erosion and pasture decline. In the rangelands, change often occurs as thresholds are reached, resulting in relatively sudden changes in pasture production and land condition. A series of average or below-average rainfall years in combination with overgrazing can also trigger rapid change. An accurate land condition assessment is made difficult by seasonal and climatic vegetation changes that can be highly variable in terms of both composition and persistence (Friedel et al. 1993; Friedel 1997).

Perennial plants are vitally important for protecting soils against wind erosion during drought (Chippendale 1963; Friedel 1993). Maintaining stocking rates close to the recommended safe utilisation rates during above-average rainfall years provides opportunities for perennial plants to increase in abundance, establish strong root systems and set seed for future growth events. Friedel (1993) found that areas that had been heavily grazed and droughted suffered wind drift and subsequent land condition decline. The soil had been blown into hummocks, which supported sparse pasture and the intermediate eroded areas were bare of useful pasture. In contrast, nearby areas of the same land type that had been only lightly grazed (but still droughted) had an even pasture cover consisting of palatable species (Friedel 1993). The literature shows that land in good condition is more stable through variable seasons (Friedel 1997; Chilcott et al. 2005) and is capable of providing carry over fodder into subsequent dry periods (Reu 2000). This suggests that good land condition would provide greater opportunity to stabilise animal production and income.

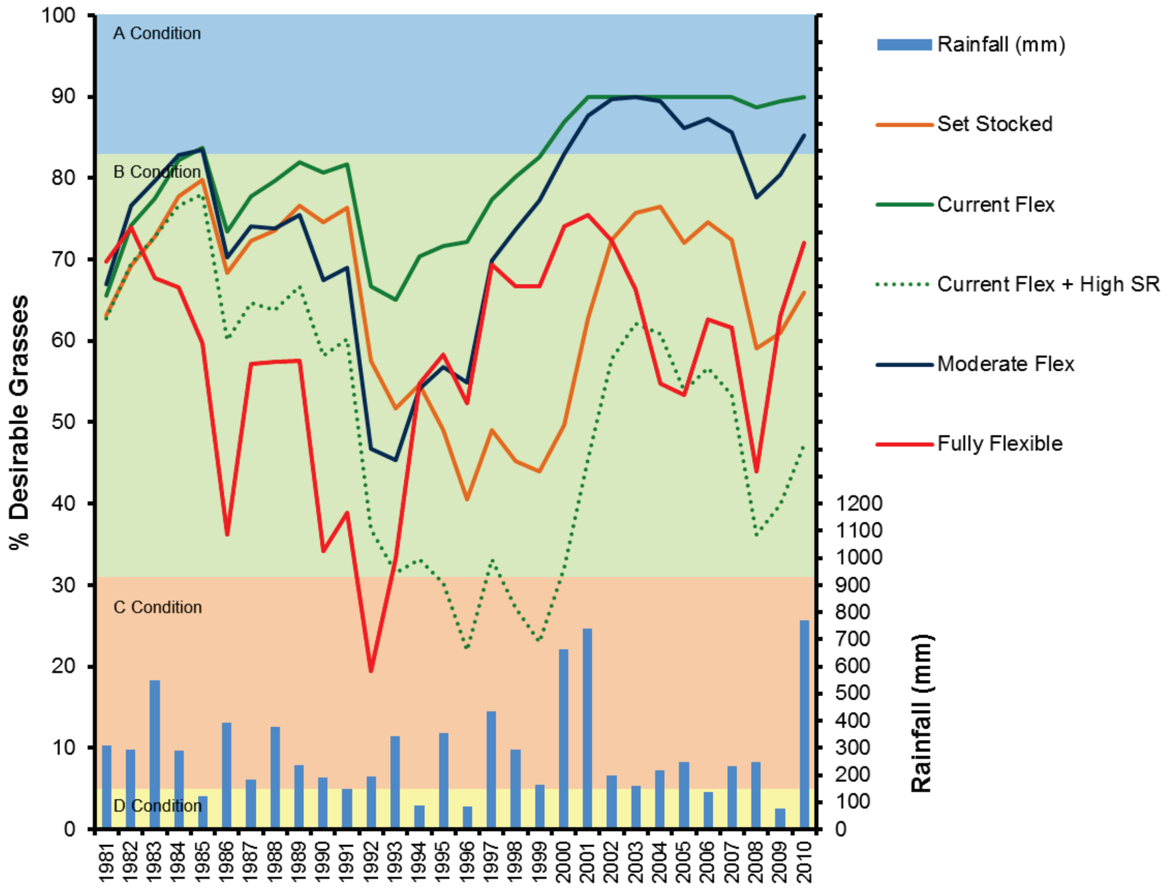


Figure 3. GRASP simulation of the impact of various flexible stocking rate strategies on land condition for open woodland in the Alice Springs region, starting in B condition (1981-2010). Percentages desirable grasses are used as an indicator of land condition (A condition ≥84%, B=32-83%, C=6-31%, D≤5%). With stocking rates that allow safe utilisation, the current industry flexibility strategy resulted in the maintenance of good land condition. Set stocking led to a decline in land condition in the poor rainfall years such as 1990, which was only able to recover due to a run of good seasons in later years. The current industry flexibility strategy with high stocking rates resulted in a decline in land condition until the very wet years in 2000, 2001 and 2010. The flexibility options shown are: set stocked (the same stocking rate for whole simulation regardless of season), current flexibility +10% to -25% per year where stocking rates were above the safe stocking rate and +20% to -30% per year where stocking rates were below the safe stocking rate to a ceiling of +30 to -50% across the simulation, moderate flexibility +30% to -50% adjustment of stock numbers per year to a ceiling of +150% to -70% across the simulation and fully flexible (i.e. essentially unlimited flexibility to track the seasons). Note that the rainfall shown is from 1 January to 31 December each year whereas the model output year is 1 May to 30 April.

Impact of stocking rate management on animal production and profitability

International and Australian literature shows that as stocking rate is increased, animal production per head declines, and animal production per unit area increases initially to a maximum and then declines (Figure 4). Most studies on intensively-managed sown pastures have shown a linear decline in animal production per head with an increase in stocking rate (Figure 4a; Jones and Sandland 1974).

The grazing research from Australian rangelands, however, provides contrasting messages in relation to stocking rate management and its impact on animal production and profit. This is probably due to the overriding influence of seasonal conditions on short research studies and the relative insensitivity of animal production to stocking rate in extensive native pastures (McIvor et al. 2010). Most trials have been run for fairly short periods (<10-15 years), and pasture systems probably have a certain degree of resilience to change. Many producers and researchers have experienced the situation where animal production has not declined under high stocking rates in the short to medium term. Animal production may be less sensitive to stocking rate in the rangelands due to much greater spatial and temporal variability (Ash and Stafford Smith 1996). In rangeland pastures, patch grazing can maintain leafy pasture and the relatively low density of plants allows animals to graze plants from the top and sides, thus allowing access to the most nutritious parts of the plant. Furthermore, there is usually a wide dietary choice available in rangeland pastures, allowing animals to select the most nutritious plants. Finally, the comparatively low stocking rates in extensive rangeland systems compared with intensive systems means that stock might not trample and foul pastures to the extent that it impacts on individual animal performance (Ash and Stafford Smith 1996).

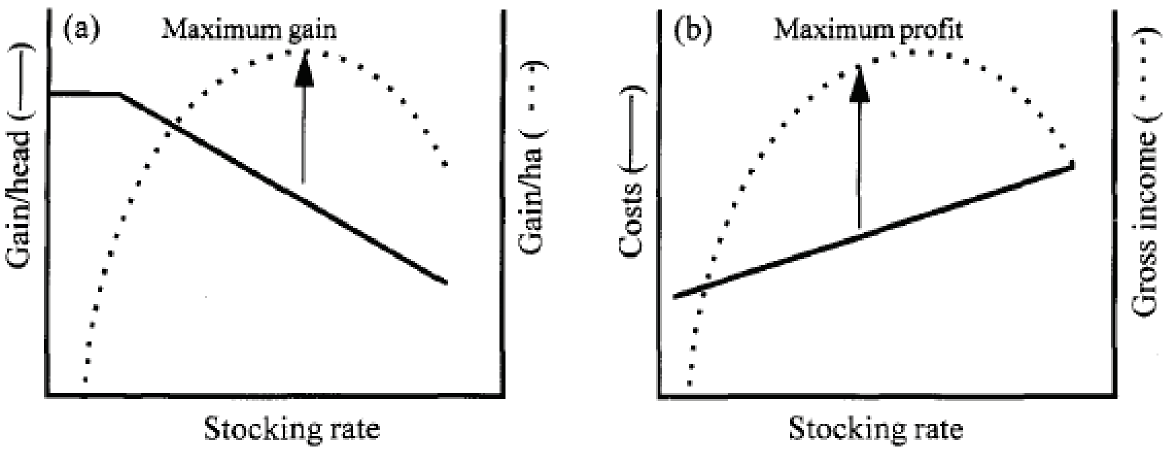


Figure 4. (a) The Jones-Sandland model relating livestock performance to stocking rate; (b) The relationship between stocking rate and economic performance based on the Jones-Sandland model (from Ash and Stafford Smith 1996).

Several trials have shown that higher-than-recommended stocking rates can result in greater productivity and profitability, although this appears to only hold true for sequences of above-average rainfall years (O'Reagain et al. 2009, 2011; McIvor et al. 2010). Despite industry perceptions that "more cattle" equates to "more profit", conservative (sustainable) stocking rates *in conjunction with* improved herd and property management can be more profitable than set-stocked enterprises running high stocking rates (Purvis 1986; Buxton and Stafford Smith 1996; Walsh 2009b, 2009e). In the recently published *Northern Beef Situation Analysis* (McCosker et al. 2010), the most profitable enterprises in Central Australia had slightly lower stocking rates, higher kilograms of beef produced per breeder, higher weaning rates and fewer overheads than the 'average' enterprises. It is also worth noting that they also had slightly smaller land area in production. For all extensive beef producing regions in their report, McCosker et al. (2010) noted "the extremely poor performance of the extensive breeder herd" as a major internal influence on enterprise profitability.

Recent advances in extensive beef cattle production highlight the link between good body condition and reproduction. At all stages of a breeder's life, nutrition is linked to her reproductive potential (McGowan et al. 2011). Prior to conception, nutrition affects the ovary and brain hormone regulators, which subsequently determine the time from calving until first ovulation and the quality of the oocyte at ovulation. Nutrition determines how long it takes a heifer to reach puberty, with studies finding that heifers in northern Australia must reach approximately 400 kg to achieve high pregnancy rates (Schatz et al. 2008). There is also evidence that nutritional stress early in pregnancy can reduce the growth rate of the progeny (Greenwood et al. 2006). Maintaining good body condition into late pregnancy has a significant impact on the likelihood of re-conception soon after calving (Schatz et al. 2008).

Stocking rate management is a key driver of individual animal nutrition. Reducing breeder death in all age cohorts and producing more kilograms of beef per breeder are key areas where enterprise performance needs to be improved (McCosker et al. 2010). Reducing the time taken to re-conceive and producing heavy, well performing offspring will increase the kilograms of beef produced by a breeder; these can be significantly enhanced by good nutrition.

5.2.4.2 The implementation of this practice

In the Alice Springs region, where the timing and amount of rainfall is variable and unpredictable, sustainable carrying capacities are based on utilisation rates that will maintain land condition over a wide range of seasonal conditions.

DPIF has calibrated the GRASP model for many land types across the NT. As a result, it is possible to produce pasture growth estimates for several land types in the Alice Springs region. Together with evidence-based recommendations for sustainable utilisation rates, carrying capacities can be calculated for properties in the Alice Springs region. Producers can ask DPIF to calculate carrying capacities at the paddock and property level. Alternatively, producers can learn how to calculate these figures by attending an Alice Springs GLM course.

One common mistake when setting stocking rates is to calculate the number of stock a paddock can carry based on the total area of the paddock. In practice, many paddocks have areas beyond 5 km from water. These areas are rarely used by stock and should not be included in the area calculations. In the Alice Springs region, it is thus recommended that stocking rates be calculated based on the carrying capacity of the land within 5 km of water points.

When matching animal demand to feed supply, producers need to be aware of the relative feed demand of different classes of livestock. Animals of different weights and nutritional demand require different amounts of feed (Chilcott et al. 2005). DPIF can provide advice on how to calculate AEs from raw stock numbers; or producers can learn how to do this by attending a GLM course.

Finally, the grazing pressure from feral and native herbivores needs to be taken into account when calculating how many stock to put in a paddock (see Chilcott et al. 2005 for appropriate conversions).

5.2.4.3 Considerations/caveats

Land type variability

Central Australia has very high spatial diversity (Stafford Smith and Morton 1990) and most paddocks will contain a variety of land types. Care needs to be taken if the land types within the paddock vary widely in the palatability of their pasture species, land condition, seasonal condition and/or productivity. Small areas of preferred country can be subjected to stocking rates considerably higher than the average for the paddock. When land type preference is highly variable, it will be necessary to either set the carrying capacity based on the area of preferred land type only or plan to destock the paddock if cattle start moving on to less preferred areas. This second strategy requires the ability to muster and move cattle as soon as the need arises or overgrazing of the preferred areas will occur. After studying three separate locations in Central Australia, Hodder and Low (1978) found that cattle prefer swamps and riparian landscapes, both of which tend to occur only as small areas. When cattle finish grazing these areas, they tend to move onto woodlands and floodplains before finally using mulga woodlands and spinifex country. Response to rainfall during the cooler months may also alter cattle land type preferences as the grasses that respond to winter rain will provide green feed at these times such as bandicoot grass (*Monachather paradoxa)* and mulga Mitchell grass (*Thyridolepis mitchelliana)*, which are common in mulga country.

Producers need to monitor preferred areas to ensure that they are not being degraded. Strategies for sustainably managing small areas of preferred land types include:

- Fencing the preferred areas with land types of similar attractiveness.
- Positioning water points more than 5 km from grazing-sensitive land types.
- Setting stocking rates based on the carrying capacity of the most preferred land type in the paddock.
- Using patch burning and/or supplements in other parts of the paddock to draw animals away from the preferred patches.
- Spelling paddocks to recover land condition on preferred patches.

Because Central Australia often experiences extended dry periods, even low stocking rates may result in overgrazing. An enterprise is likely to need resilient landscapes to survive a sequence of very dry years to avoid a decline in land condition (Pickup and Stafford Smith 1993). Strategies might include reducing stock numbers on fragile land types and/or moving the core herd onto more resilient land types such as mulga, buffel-dominated pastures or spinifex.

Top feed

Central Australian pastoralists often ask how to allow for top feed (browse) when calculating stocking rates. Several studies of cattle diets have been undertaken in Central Australia and they have found that at various times, browse can be a large proportion of the diet. Squires and Low (1987) found that browse contributed up to 43% of the diet in acacia shrubland at the end of winter and even more when the flush of annual species had passed. A similar study found that cattle did not consume any browse when grasses and forbs were green following average summer rain (early December to the end of February) (Squires and Siebert 1983). When the pasture had dried off however, browse contributed up to 20% of the diet. An important point to make here is that when pastures are at their most vulnerable to grazing (early growth prior to full root development and seeding), cattle select no or little browse in their diet. If a stocking rate is applied assuming that browse is a contributor to the forage available, then the grasses could be overgrazed when they are at their most vulnerable stage. In the GRASP model simulations described previously, top feed was simulated by allowing the cattle in the model to reduce the "pasture" to a minimum level of 50 kg/ha. In practice, this is lower than recommended for sustainable pastoral production and this artificial baseline should be seen as a way to simulate the use of top feed in a model rather than as an on-ground management practice. The current recommendation from DPIF for incorporating top feed into a Central Australian pastoral enterprise is to treat it as a "buffer" that can be drawn upon in times of need rather than incorporating it into a formal forage budget.

5.2.5 Essential management action 2: use forage budgeting to adjust stocking rate to seasonal conditions

If stock numbers are rigidly applied based on the long-term carrying capacity of the paddock/property (i.e. fixed stocking at the carrying capacity), then it follows that there will be years when potential additional production will be forgone (i.e. in good seasons) and years when animal production and land condition declines could occur (i.e. in poor seasons). Model simulations indicate that fixed stocking rates (even when set at the "safe" stocking rate derived using the GLM method) experience poorer growth and lower pasture condition (see Figure 2) than nearly all other more flexible stocking strategies. If stocking rates are higher than recommended, then land condition decline can occur as a result of overstocking in average and dry years. Friedel (1997) found that heavy grazing of relatively undegraded pasture in poor rainfall years can quickly shift country towards a degraded state.

If stocking rates are allowed to "creep up" over a period of favourable seasons, a below-average rainfall year can lead to overgrazing of the preferred grasses and a decline in ground cover. In this situation, stocking rates may need to be reduced below the long-term carrying capacity in order to protect pastures from long-term damage. Plans should be developed for a progressive reduction in stocking rates during deteriorating seasonal conditions to avoid crisis management. There will also be economic benefits in selling some cattle before regional conditions trigger large scale stock reductions. It is recommended that producers adjust stocking rates at least twice a year if necessary (i.e. at the end of summer around March-April and then again towards the end of winter (September)). Where it is feasible, reducing stocking rates during summer if rains are poor can help protect land and livestock condition.

Stocking rate decisions should be based on an assessment of current pasture conditions. This should consider patterns of grazing distribution within paddocks (i.e. change in preference of land types and grazing distance from water). Where they have been developed, plant and soil indicators should be used to inform decisions about the need to reduce stocking rates to avoid land degradation as pasture availability and seasonal conditions decline. The condition of perennial grass tussocks (such as the amount of residual biomass or stubble height) are important indicators of future plant survival and pasture productivity.

Seasonal forecasts can be used in areas where they have good reliability to aid stocking rate decisions for the coming growing season. In the Alice Springs region, producers have little confidence in seasonal forecasting (White and Walsh 2010) and stocking rates are typically determined using visual assessments of pasture, cattle condition and gut feel. Given the unpredictability of the seasons, producers tend to make assessments of feed available at a given point in time rather than try to predict future pasture production, although decision dates are often based on historical events. For example, a producer featured in a local case study moves to reduce stock numbers if no rain has fallen by the end of February because the chances of receiving two growth events before the end of summer is unlikely (Walsh 2009a). Regardless of the method used, the limitations of seasonal forecasts and historical records should be acknowledged and producers must be prepared to adjust stock numbers if conditions do not turn out as anticipated.

5.2.5.1 Evidence supporting this management action

Bio-economic modelling demonstrates how high rainfall variability can interact with stocking rate strategy to dampen or magnify annual stocking rate variability. In the Alice Springs region, a fully flexible stocking rate strategy results in large swings in annual stocking rate, with very high stocking rates occurring in high rainfall years (Figure 5). Invariably, stocking rates fall markedly in response to low rainfall, which raises questions about the practicality, risks and economic performance of such an approach. Current and moderate levels of stocking rate flexibility (where limits are placed on the amount of adjustment implemented from year to year) have the effect of dampening inter-annual variability in stocking rate (Figure 5) which is likely to reduce market and land condition risk as described previously.

Modelling output for the region confirmed that current and moderate levels of flexibility lead to the best land condition outcomes (Table 3). This is because these strategies are effectively “understocked” in the better rainfall years, which allows for land condition improvement at those times. Land that started the model simulation in B condition stayed in B condition under the current industry flexibility strategy, but only if combined with safe stocking rates. Under a fully flexible strategy, land condition performance was relatively poor because stocking rates were sufficiently high in the good years to prevent recovery (Table 3).

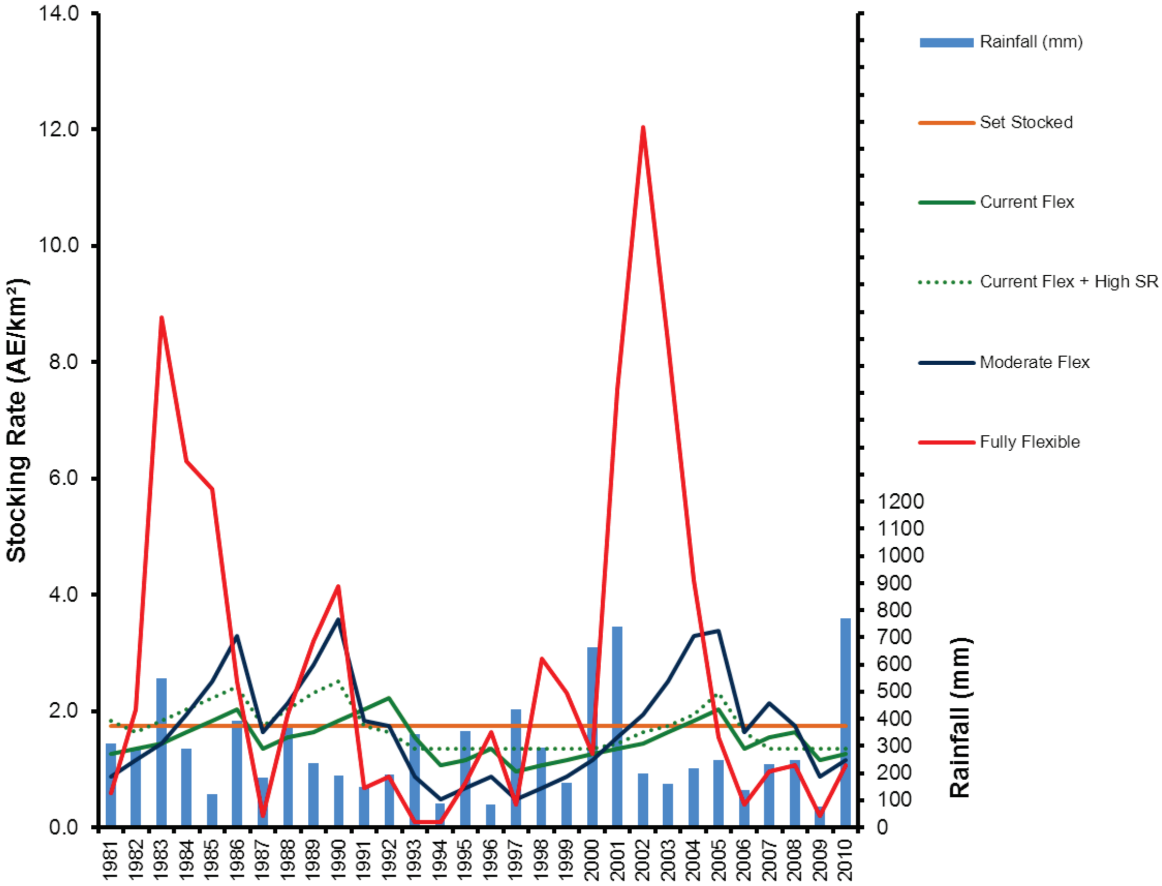


Figure 5. GRASP simulation of the effect of stocking rate flexibility strategy on annual stocking rate for open woodland in the Alice Springs region, starting in B land condition (1981-2010). Stocking rate generally stayed between 0-2 AE/km^2 for most strategies, with only the fully flexible strategy achieving higher stocking rates in very good seasons. The current industry flexibility strategy with high stocking rates remained fairly constant because the stocking rate was not allowed to drop lower than 50% of the starting stocking rate in any year, even though this meant that the safe utilisation rate was often exceeded. The flexibility options shown are: set stocked (the same stocking rate for the whole simulation regardless of seasonal pasture growth), current flexibility +10% to -25% per year where stocking rates were above the safe stocking rate and +20% to -30% per year where stocking rates were below the safe stocking rate to a ceiling of +30 to -50% across the simulation, moderate flexibility +30% to -50% adjustment of stock numbers per year to a ceiling of +150% to -70% across the simulation and fully flexible (i.e. essentially unlimited flexibility to track the seasons). Note that the rainfall shown is from 1 January to 31 December each year whereas the model output year is 1 May to 30 April.

Table 3. Land condition performance of various land types and starting land condition classes under different stocking rate flexibility options (1981-2010). Flexibility strategies are described in more detail in Figure 3, Section 5.2.4.1. The best performing strategies are highlighted in yellow for each land type. Average percentages desirable grasses are used as an indicator of land condition (A condition ≥84%, B=32-83%, C=6-31%, D≤5%). The current industry flexibility strategy maintained good (B) land condition and also resulted in land condition improvement from C to B condition when appropriate stocking rates were used. However, when combined with high stocking rates, the current industry flexibility strategy resulted in land condition decline for all land types. Similarly, the higher stocking rates achieved by the fully flexible strategy during above-average rainfall years prevented the improvement of land condition under that strategy.

	Stocking rate flexibility strategy				
Land type and starting land condition	**Fixed (set stocked)**	**Current (modest) flexibility**	**Current (modest) flexibility with high stocking rates**	**Moderate flexibility**	**Full flexibility**
Alluvial C condition	28	69	7	62	23
Mulga C condition	21	79	6	60	46
Oatgrass C condition	19	55	5	60	44
Open woodland B condition	65	81	51	75	58
Open woodland C condition	22	55	9	47	38
Spinifex B condition	69	73	34	60	34

Live-weight gain per head (LWG/head) was optimised under current industry levels of stocking rate flexibility when teamed with safe stocking rates (Table 4). The moderate and fully flexible strategies tended to achieve lower LWG/head. This is because they had higher stocking rates in better seasons, which prevented land condition recovery and reduced the available forage per head. The fixed stocking rate strategy performed poorly (Table 4) because stock numbers were not reduced in dry seasons, leading to overgrazing and subsequent land condition decline. Current industry flexibility with high stocking rates resulted in the lowest LWG/head for all land types, regardless of starting land condition.

Table 4. Average LWG/head (kg/year) for various land types and land condition classes under different stocking rate flexibility strategies (1981-2010). The best performing strategies are highlighted in yellow for each land type. For land starting in B condition, the current flexibility strategy with safe stocking rates was essentially understocked during above-average rainfall seasons and therefore cattle had more feed per head and could select the most nutritious pasture, resulting in higher LWG/head compared with other strategies. High stocking rates in combination with current industry flexibility had the worst performance because forage supply would often be inadequate.

	Stocking rate flexibility strategy				
Land type and condition	**Fixed (set stocked)**	**Current (modest) flexibility**	**Current (modest) flexibility with high stocking rates**	**Moderate flexibility**	**Full flexibility**
Alluvial C condition	103	152	63	140	89
Mulga C condition	56	139	23	108	82
Oatgrass C condition	79	119	31	120	98
Open woodland B condition	125	148	105	134	112
Open woodland C condition	75	115	55	101	89
Spinifex B condition	89	92	52	80	57

The importance of an appropriate stocking rate is again highlighted in Table 5 for LWG per hectare (LWG/ha). LWG/ha for all land types did not vary greatly between the current and moderate levels of flexibility provided that stocking rates were appropriate. The fully flexible strategy achieved higher LWG/ha (Table 5) by dramatically increasing stocking rates to very high levels (8 to 12 AE/km^2) in the best seasons (Figure 5). When stocking rates got too high, land condition declined to C condition. When the current industry flexibility strategy was teamed with high stocking rates, average LWG/ha was negative for two land types in C land condition (Table 5).

Table 5. Average LWG (kg/ha) of various land types and land condition classes under different stocking rate flexibility strategies (1981-2010). The best performing strategies are highlighted in yellow for each land type. The fully flexible approach achieved the best LWG/ha for many land types because stocking rates rose to very high levels (8 to 12 AE/km^2) during good seasons. However, as shown earlier, this production benefit was at the expense of land condition. High stocking rates in combination with current industry flexibility had the poorest LWG/ha performance, with some land types achieving negative LWG/ha.

	Stocking rate flexibility strategy				
Land type and condition	**Fixed (set stocked)**	**Current (modest) flexibility**	**Current (modest) flexibility with high stocking rates**	**Moderate flexibility**	**Full flexibility**
Alluvial C condition	1.0	1.8	0.5	2.2	1.7
Mulga C condition	0.2	1.2	-0.3	1.1	2.6
Oatgrass C condition	0.4	0.7	-0.4	1.1	1.9
Open woodland B condition	2.3	2.3	1.9	2.4	4.0
Open woodland C condition	0.6	1.1	0.5	1.0	2.9
Spinifex B condition	0.4	0.4	0.2	0.3	0.2

Thus, the modelling indicates that a fully flexible stocking rate approach would provide the best LWG/ha (Table 5); however, this is achieved at the expense of land condition (Table 3). The economic analysis showed that whilst the fully flexible approach achieved the best average profit, financial losses occurred in 50% of years and the maximum annual loss was very high (more than $2.5 million) (Table 6). A fully flexible stocking rate strategy relies heavily on the very good seasons to make up for the big losses. A fully flexible strategy is also almost impossible to apply in Central Australia due to the practicalities of purchasing, selling and transporting large numbers of stock in very short time frames. As previously discussed, failure to reduce numbers rapidly can cause declines in land condition that persist for many years and impacts negatively on pasture productivity and profitability. It should be noted that the financial performance of the fully flexible strategy would have been even worse if the simulation run had not included the very wet year of 2010.

Table 6. Profit measures for various stocking rate flexibility strategies (1981-2010). The fully flexible strategy achieved the highest annual average profit but experienced a financial loss in 50% of years. The current industry flexibility strategy with safe stocking rates provided the second highest annual average profit and had the lowest number of years in which a loss was made. The moderate flexibility strategy performed worse than the current flexibility strategy due to the additional costs of buying and transporting stock for no extra LWG/ha. Current industry flexibility with high stocking rates had the lowest annual average profit and the highest number of years in which a loss was made.

	Stocking rate flexibility strategy				
Profit measures	**Fixed (set stocked)**	**Current (modest) flexibility**	**Current (modest) flexibility with high stocking rates**	**Moderate flexibility**	**Full flexibility**
Average	$118 806	$194 669	$53 061	$172 644	$354 230
Minimum	-$124 317	-$360 274	-$454 010	-$674 977	-$2 565 236
Maximum	$471 048	$541 679	$888 265	$803 613	$6 853 649
Number of negative years	8	6	18	12	15
Net present value	$2 031 560	$2 867 322	$1 056 596	$2 821 304	$6 200 504

In summary, the current industry approach to stocking rate flexibility (when used in conjunction with appropriate stocking rates) offered the best balance between land condition and LWG/head outcomes and also performed well on a LWG/ha basis. Under this strategy, the profit measures also performed well; but perhaps more importantly, financial losses were only experienced one year in five.

Moderate flexibility performed worse than current flexibility because the additional flexibility added more costs for buying and transporting stock, for no extra LWG/ha. As stocking rate flexibility increased, so did the range in annual profit and the number of years with a loss, which highlights the higher risk associated with implementing higher flexibility strategies.

No long-term studies of variable stocking rates have been conducted in Central Australia. However, the Wambiana grazing trial in Qld does provide direct support for the model output presented above. The variable stocking regime (equivalent to the fully flexible strategy) at Wambiana did not perform any better financially than set stocking and experienced problems (both financial and land condition) in the transition from good to poor years (O'Reagain et al. 2009). Although the Wambiana trial showed there was potential to make more money by taking advantage of a run of above-average seasons, there was no indication of how this approach would work when one above-average year occurs in isolation amongst average to below-average years. Given that it is not possible for a producer to know whether they are experiencing an isolated good year or the beginning of a sequence of good years, it is difficult to confidently recommend a highly flexible stocking strategy, particularly for breeder operations. Current (modest) levels of stocking rate flexibility thus appear to provide the best compromise between land condition, animal production and profit outcomes, and are practical to implement.

Inter-annual variation in stock numbers using the typical industry approach to stocking rate management is relatively small, but decisions still need to be based on reliable information about markets, meteorology, finances, production levels and ecological conditions (Pickup and Stafford Smith 1993). Annual forage budgeting is the key management tool for making decisions on stocking rate adjustments. The practical implementation of forage budgeting is discussed in the following section.

5.2.5.2 The implementation of this practice

In the Alice Springs region, pastoralists will often make the decision about when to muster stock based on an assessment of available feed. In dry years, mustering can occur as early as February and in wet years it may be as late as July. Many properties will conduct two musters during the year. The most common months for mustering are April and September, which makes sense for Central Australia as these dates effectively signal the end of the potential summer and winter growing periods. Forage budgets done in these months can provide information at a time when paddock stock numbers can be adjusted. Producer feedback from regional workshops (White and Walsh 2010) indicated that stocking rate adjustments of +/-20% per annum are typical of what is achievable via normal station management (i.e. weaning and turning off steers/growers/culls). Additional adjustments in stocking rates come from retaining more heifers (if building numbers) or selling more aggressively in response to a below-average season.

A forage budget should be developed at the end of summer for the coming 12 months (i.e. until the following year's first round muster). Estimates of standing forage biomass at the end of summer, together with recommended sustainable utilisation rates and target residue levels can subsequently be used to determine stock numbers for the coming 12 months. This approach allows for adequate pasture residue going into the start of the next summer growing season and buffers against the possibility of poor summer rainfall. In the Alice Springs region, the recommended end-of-year residue target is ~200 kg/ha (Chilcott et al. 2005).

Standing biomass (kg/ha) is normally estimated in several areas of the paddock/property. This can be done using visual estimates, photo standards or cutting actual samples. Several standing biomass estimates should be made for each land type within the paddock. The estimates for each land type can then be averaged and multiplied by the area of the land type within 5 km of water in the paddock. It should be noted that the total biomass <u>does not</u> represent the total amount of pasture available for grazing. The pasture available for grazing is determined by adjusting the total biomass for such factors as the safe utilisation rate for the land type, the desired level of residual biomass at the beginning of the next growing season and an estimate of pasture detachment rates. Producers can ask DPIF for advice on calculating a forage budget. Alternatively, they can learn how to do forage budgeting by attending an Alice Springs region GLM course.

Large paddock sizes and variability in rainfall and land types can make it difficult to accurately assess forage availability in Central Australia. Conservative stock numbers thus allow some buffering against those times when errors are made.

When matching animal demand to feed supply, producers need to be aware of the relative feed demand of different classes of livestock. Animals of different weights and nutritional demand require different amounts of feed. The grazing pressure from feral and native herbivores also needs to be included when calculating the number of animals to be placed in a paddock. DPIF can provide advice on calculating AEs from stock numbers or producers can learn how to do this by attending a GLM course.

Once cattle are put into a paddock, the pasture should be checked regularly to ensure that overgrazing is not occurring, particularly on preferred land types. If the feed supply is deteriorating faster than expected, stock numbers should be reduced. Another forage budget can be conducted to determine how many cattle to remove in order to meet end-of-season residue targets.

5.2.5.3 Considerations/caveats

Large, frequent adjustments of stock numbers can incur high costs and be labour-intensive. Attracting and retaining labour are recognised as some of the main issues affecting the profitability of pastoral enterprises (Leigo 2004).

Using forage budgeting in isolation to calculate potential increases in stocking rate is problematic given that it is usually based on what pasture has already grown rather than on what will grow in the future. Furthermore, there are many other factors that affect the practicality, desirability and riskiness associated with short to long-term increases in stocking rate (i.e. forage quality, future pasture growth, production system, market risk, freight costs and weed invasion). As an alternative to increasing stock numbers, good growing seasons provide an opportunity to improve individual animal performance, spell pastures to improve land condition (see Section 5.3.4) and/or build up fuel loads to use fire to manage woody plant populations (see Section 5.5).

5.2.6 Complementary management action 1: implement pasture spelling

Spelling pastures in good land condition can increase the amount of pasture grown and/or reduce the amount consumed. This strategy can be used to increase the total feed supply or defer when it is consumed. Pasture spelling also has a role in restoring and maintaining land condition.

5.2.6.1 Evidence supporting this management action

Cattle tend to return repeatedly to graze preferred patches. If pastures are not spelled, these preferred patches become chronically overgrazed, less palatable species increase and land condition declines. By allowing patches to regrow during a growth event, they become more like the remainder of the pasture and animals are less likely to overgraze them when grazing resumes.

Palatable perennial grass species are particularly sensitive to defoliation early in their growth cycle (Ash et al. 1998; Chilcott et al. 2005). In order to maintain good land condition, it is important that perennial grasses are allowed to set seed so that new plants can establish in future. Palatable annual species can also form a large bulk of useful feed in many land types. Annual species complete their life cycle within a growth event and must produce seed in order for germination to occur in future growth events. In Central Australia, growth events are described as approximately 50 to 58 mm of rain with positive soil moisture levels maintained for about four weeks (Pickup and Stafford Smith 1993; Slatyer 1962). It is likely that there will be only two growth events expected in an average year in the northern Alice Springs region and half to one and a half growth events per year in the southern Alice Springs region (Slatyer 1962). These growth events can occur in the winter months (resulting in nutritious winter herbages) and thus spelling at any time of the year can be effective in Central Australia. However, October to March is generally acknowledged as the most productive time for grass growth and is likely to achieve the best outcome from spelling.

Although spelling is most effective when it coincides with a growth event, the unpredictable nature of rainfall in Central Australia means that it is often impractical to move stock in response to a growth event. The exception to this might be rotational grazing strategies involving relatively small paddocks with no surface water (Materne 2010a). Spelling for the entire summer period allows pasture species to replenish their root reserves <u>and</u> allows them to set seed. Pastures dominated by oatgrass can maintain their nutritional quality even once hayed off (Allan and Wilson 2006) and therefore still provide useful forage when the paddock is reopened for grazing. A practical method for achieving spelling is to remove cattle from the paddock during a second round muster in September or October.

While the low utilisation rates experienced during good seasons are beneficial for managing land condition, spelling is recommended because animals still preferentially graze parts of the landscape. During the 1970s, investigations were undertaken to determine land type preferences of cattle in Central Australia (Hodder and Low 1978; Low et al. 1981). The results showed that cattle mostly preferred woodland and floodplains, particularly when feed was green and abundant during spring and summer. Foothill fans were used when feed was moderately abundant and drying off, particularly during winter. Areas dominated by less palatable perennial grasses were used after small rain events during dry periods as they quickly produced green pick. Cattle moved into mulga annual pastures as the seasonal pasture condition declined further. When feed conditions became poor (e.g. dry and sparse), cattle moved into the hills and into mulga areas dominated by less palatable perennial grasses. Water points and fences can be used to manipulate grazing distribution. For example, large areas of preferred country can be fenced to allow for occasional spelling. This is particularly important given that cattle prefer to graze these landscapes when the pasture species are regenerating and setting seed immediately following rain.

Many producers are aware of the positive effects of spelling from their observations of holding paddocks and laneways. These areas, which tend to get very heavily grazed for short periods during mustering, are usually destocked for the remainder of the year. Under this regime, the paddocks and laneways respond very well to rainfall and are often in better land condition and have a larger body of feed than nearby paddocks that are grazed continuously.

A recent research trial conducted at Mt Riddock Station in Central Australia investigated an eight paddock rotation of steers on buffel grass (*Cenchrus ciliaris*) pastures in fair to good condition. The four smaller paddocks ranged in size from 3.1 km^2 to 6.4 km^2 and covered a total area of 20.5 km^2 while the four larger paddocks ranged in size from 10.2 km^2 to 13.5 km^2 and covered a total area of 46.6 km^2 (Materne 2010a). The rotation used short graze periods (average two to four weeks per paddock) and the total number of rotations per year was varied depending on forage and stock availability (Materne 2010a). After five years of operation, the results show that indicators of land condition, such as perennial grass frequency and cover, stayed consistently high in these rotationally-grazed paddocks. This trend persisted through a range of above and below-average seasons and suggests that matching stocking rate to forage supply and regular spelling achieved via rotation was able to maintain land condition (Materne 2010a).

At nearby Woodgreen Station, the pastures are maintained in good land condition regardless of seasonal quality. Approximately two thirds of the property is spelled at any point in time. Small herds of steers and older cows have two paddocks, between which they are rotated at approximately six-monthly intervals. Small breeder herds of about 50 head each have three paddocks of equal carrying capacity through which the cattle are rotated (Walsh 2009e). This system achieves a reliable, consistent turnoff of high-quality finished cattle and has led to a marked increase in palatable perennial grasses in productive country and improved land condition (Purvis 1986). The success of this frequency and duration of spelling is supported by recent bio-economic modelling undertaken for the Alice Springs region (see below).

Model simulations

Using the GRASP model, a range of spelling strategies were compared (e.g. frequency of one-in-four year spell, one-in-two year spell and spelling every year). B land condition could be maintained or improved by either very low continuous stocking rates or with moderate stocking rates and frequent six-month spelling every one or two years (Table 8). For oatgrass (*Enneapogon* spp.) and open woodland land types, land condition could be maintained or improved with higher stocking rates, but only if more frequent spelling was undertaken. At very low stocking rates (0.3 AE/km^2) spelling did not provide any additional benefit in terms of land condition because this stocking rate was ecologically sustainable anyway.

Table 7. An example of GRASP analysis of the effect of spelling and stocking rates on land condition for oatgrass pastures in the Alice Springs region, starting in B condition. The duration of spelling was six months starting on 1 December. Results show the average of 20 different lots of 29 year climate windows each starting on a different date between 1900 and 1975. Average percentages desirable grasses are used as an indicator of land condition (A condition ≥84%, B=32-83%, C=6-31%, D≤5%). Highlighted cells show where starting land condition was maintained or improved.

	Average desirable grasses (%)			
	Spelling strategy (six month spell)			
Stocking rate while grazed (AE/km^2)	**No spell**	**1 in 4 year spell (spelled one eighth of the time)**	**1 in 2 year spell (spelled a quarter of the time)**	**Spell every year (spelled half the time)**
0.3	88	89	89	89
0.6	69	85	88	89
1.2	34	51	66	87
1.8	21	32	44	81

For B condition open woodland, a stocking rate of 1 AE/km^2 maintained land condition without the need for spelling (Table 8). With a one-in-two year (or more frequent) six-month spell, this stocking rate led to an improvement to A condition (Table 8). These simulations thus demonstrate that it is important to incorporate spelling in order to maintain land in A or B condition unless stocking rates are quite low.

Table 8. An example of GRASP analysis of the effect of spelling and stocking rates on land condition for the open woodland land type in the Alice Springs region, starting in B condition. The duration of spelling was six months. Results show the average of 20 different lots of 29 year climate windows each starting on a different date between 1900 and 1975. Average percentages desirable grasses are used as an indicator of land condition (A condition ≥84%, B=32-83%, C=6-31%, D≤5%). Highlighted cells show where the starting land condition was maintained or improved.

	Average desirable grasses (%)			
	Spelling strategy (six month spell)			
Stocking rate while grazed (AE/km^2)	**No spell**	**1 in 4 year spell (spelled one eighth of the time)**	**1 in 2 year spell (spelled a quarter of the time)**	**Spell every year (spelled half the time)**
0.5	87	88	88	89
1	63	77	85	88
1.5	35	57	70	86
2	24	39	55	81

The modelling indicates that for B condition pastures, spelling for six months every year but doubling the stocking rate during the graze period achieved better land condition than continuous grazing at the same effective stocking rate. For example, open woodland that was spelled half the time and stocked at 2 AE/km^2 (i.e. an average annual stocking rate of 1 AE/km^2) achieved better land condition (81% desirable grasses) than continuous grazing at 1 AE/km^2 (63% desirable grasses) (Table 8).

There are also some additional benefits of spelling using a rotational grazing system. The need to make timely decisions on stock movements may result in greater attention to pasture dynamics, which in itself may improve ecological understanding and land condition (Kain and Cowley 2008). Handling stock more frequently can result in quieter, more controlled and more productive animals. It also provides an opportunity to more readily identify and remove poor performers and animals with poor temperament (Walsh 2009e).

5.2.6.2 The implementation of this practice

Where to start

Many pastoralists who routinely implement spelling started out doing it on their most productive country. This approach offers the greatest potential to optimise future profitability by having the best land in good condition. Productive land types are often quite sensitive to grazing pressure and spelling will help to maintain good land condition. This sensitivity to grazing also means that stocking rate must be appropriate because the potential for overgrazing when non-spelled paddocks are “stocked up” is very high. There is perhaps a slight trend in the industry towards starting a spelling program in paddocks with dry stock as breeders can be a little more challenging to move with calves. Nevertheless, producers do successfully move mobs of breeders with careful monitoring to ensure all calves are in hand. In a controlled mated herd, allowing two weeks after the last birth has been found to be sufficient to successfully move all animals (Materne 2010b). At Rockhampton Downs Station in the NT, it was observed that the higher stock density in the rotation kept the bulls in closer proximity to the cows and improved conception rates (Scott et al. 2010).

Experienced producers advise implementing a spelling program by improving herd quality, thinking long-term, researching the environment, visiting other strategies, beginning with a small strategy, monitoring and recording results and using conservative stocking rates (Walsh 2009a, 2009b, 2009c, 2009d, 2009e). One producer interviewed for a series of case studies also advised “don’t give up”. This is an important message for two reasons. Firstly, anticipated benefits and improvements in land condition may only be maximised when very good seasons are experienced. This is supported by the model simulation in Figure 6, which demonstrates that paddocks grazed during very dry years had a slower rate of land condition recovery than those being spelled, but they did eventually reach a level comparable to those ungrazed during the dry period if regular spelling was conducted. The land condition in these paddocks was also always better than in continuously-grazed paddocks of the same land type. The second reason for persevering is that it can take some time for both animals *and their handlers* to get used to a new grazing strategy (Provenza 2003; Scott et al. 2010).

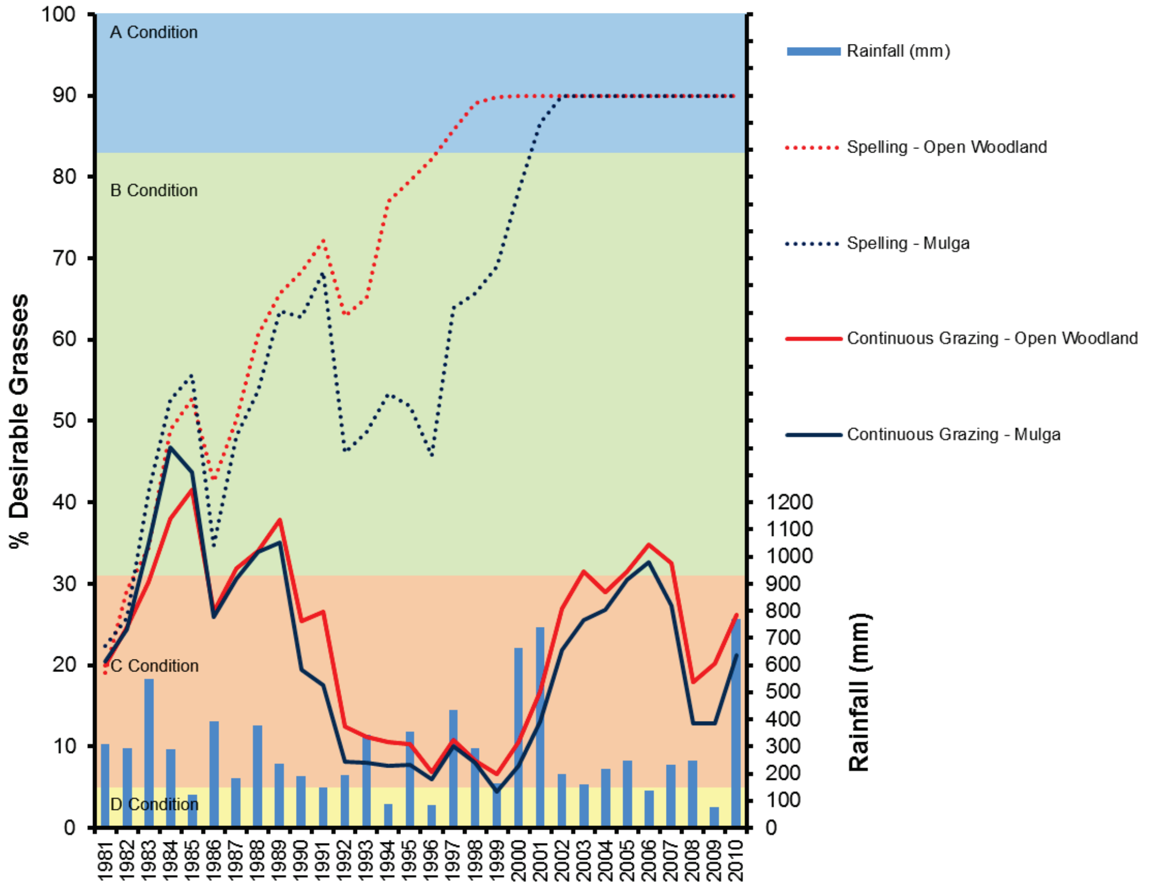


Figure 6. The effect of a spelling regime that alternates a full year of spelling with a full year of grazing on mulga and open woodland land types starting in C condition. This simulation indicates that once land is in good (A or B) condition, this spelling regime can maintain good land condition. In the absence of spelling, land condition did not improve by the end of the simulation for either land type. Percentages desirable grasses in the pasture are used as a proxy for land condition. Note that the rainfall shown is from 1 January to 31 December each year, whereas the model output year is 1 May to 30 April.

How to spell

In practice, to achieve summer spelling (i.e. during the most likely growing season), most producers will probably need to remove cattle from the paddock during the second round muster.

Another option is to turn off some bores and troughs in large paddocks. At Lyndavale Station in the southern NT, breeder herds are grazed in one very large mulga paddock with 25 water points (Walsh 2009b). The bores have been situated far enough apart to ensure that grazing areas do not overlap, which means that cattle tend to remain on their assigned watering points. New heifers are placed on bores with others of their age group and live their entire lives in the same area. When these breeders are about eight years old, they are culled and the bore area is spelled until replacement heifers are introduced (Walsh 2009b). Appropriate stocking rates that ensure adequate fodder within the grazing area of any given bore area have ensured the success of this strategy.

Turning water points on and off can also be used to rotate one mob of cattle through a paddock to spell bore areas. The trial at Rockhampton Downs Station aimed to move cattle to a new watering point approximately every six weeks. After considerable challenges moving cattle at the beginning of the trial, the managers devised a technique whereby the new watering point was turned on and the old watering point was turned off the day before the planned move. This provided a cue for cattle that the move was about to take place and the task of moving the herd only required one person and one vehicle once the cattle understood the system

(Scott et al. 2010). The Rockhampton Downs rotational system was situated in a paddock containing quite uniform Mitchell grass pastures and resulted in a relatively even use of the paddock. However, where paddocks contain a number of land types, cattle will often walk long distances to access highly preferred country (Kain 2008). This was demonstrated in a trial at Idracowra Station south of Alice Springs, which involved moving a water trough 500 m along a fixed pipeline each week. The producer found that cattle needed to be mustered to the new trough location for the first few weeks, but soon learnt how to follow the trough. However, cattle would walk more than 5 km to get back to highly preferred pasture types (Kain 2008). Although the costs of infrastructure development and maintenance are very high, fencing remains the most secure way of controlling cattle distribution where land types vary widely in their attractiveness to cattle.

If the goal of spelling is to grow more feed, the spelling will need to occur during the growing season. If the aim is to retain feed for later in the year, then spelling can be planned for any time. Many producers are wary of "saving" large bodies of feed because they are a significant fire risk. A prescribed burn during the winter months may be required to manage this risk. When retaining feed for a later date, producers need to be aware of natural rates of pasture decline. Annual and forb-based pastures have relatively fast breakdown rates, which can reduce standing 'haystacks' to one third of starting biomass in one year through natural leaf fall alone. Frost can also greatly reduce standing pasture quality and further increase natural breakdown rates. These factors need to be taken into account when forage budgeting in spelled paddocks.

Indicators of when to move stock

Unless the cattle from the paddock being spelled are agisted or sold, spelling can sometimes result in large numbers of stock being held in other paddocks. This indicates a potential risk of overgrazing if cattle numbers are not assessed correctly or they are not moved at appropriate times. There are several techniques that can be used to determine when cattle should be moved. It is commonly observed that cattle condition declines more slowly than the condition of the feed. Behavioural clues such as cattle distribution and vegetation community preference may be a far more valuable aid in decision-making than animal body condition (Hodder and Low 1978). There are models that can help determine the spatial distribution of cattle in a given landscape using remote sensing technology (Pickup and Bastin 1997). This technology could be useful for establishing likely grazing preferences and identifying useful monitoring locations.

Many pastoralists will monitor the defoliation of preferred pasture species as an indicator of the need to move cattle (Purvis 1986; Walsh 2009b, 2009c, 2009d, 2009e). Short term indicators used include the amount of ground cover present, robustness of perennial grass butts, the amount of biomass remaining, the level of defoliation on preferred species and the amount of pasture that has not been grazed. Slightly longer term indicators of grazing impact include an assessment of the pasture utilisation rate and pasture species composition, particularly the presence or absence of preferred plants. The maximum utilisation levels targeted in any given year should always be considered in the context of seasonal pasture growth and the long-term carrying capacity (Walsh and Cowley 2011). Plant species composition alone may be too slow to identify land condition decline as it does not necessarily change until the subsoil had been exposed (Friedel et al. 1993). Other indicators of soil change and protective cover should be considered. In semi-arid landscapes; soil losses are very high when vegetation cover is below about 8% and very low when cover is above 50% with rapid change in between (Wilcox and Wood 1989).

5.2.6.3 Considerations/caveats

Two common problems are seen in the implementation of pasture spelling. One problem occurs when the animals removed from the paddock to be spelled are put into other paddocks without regard to the increase in stocking rate in those paddocks. Overgrazing some paddocks in order to achieve spelling in another defeats the purpose of the exercise. To overcome this problem, spelling can be done during good seasons (when there is more pasture available), animals should be put into paddocks with spare grazing capacity, or excess animals should be sold or agisted. Some paddocks may have capacity for additional livestock during good rainfall years due to the extra watered area provided by semi-permanent surface waters. Such paddocks can provide a temporary home for stock from paddocks that are being spelled.

The other problem commonly seen is that some producers consider that destocking paddocks during droughts is the same as spelling. Destocking during periods of little to no pasture growth might protect the remnant pastures and soils in the paddock but does not allow pasture plants to increase their root reserves or produce seed. Spelling thus needs to occur during periods of active pasture growth to maximise its benefit.

Pest animals (e.g. rabbits and kangaroos) can also negate the effects of spelling if they are in high numbers. A study on the effect of large numbers of rabbits found that they did not necessarily degrade the herbage layer but they did restrict its ability to respond to improving seasonal conditions (Foran 1984). Some producers have had success in implementing thorough control programs for rabbits prior to beginning land restoration works (Bastin 1991b) and a similar approach may be beneficial in a spelling program.

5.2.7 Complementary management action 2: implement prescribed burning

For land in good condition, fire is most likely to be useful as a tool for providing firebreaks and for controlling shrub seedlings after very wet seasons.

Very wet rainfall periods (e.g. 2000-01 and 2010-11) are often followed by large wildfires. Prescribed burning (prior to and in response to wildfire seasons) can help reduce and break up fuel loads in order to protect pasture from broad-scale, uncontrolled burning. Alternatively, if key feed assets and infrastructure are not at risk, wildfires can be left to burn in order to achieve scrub thinning.

Occasionally, fire can also be used to influence where animals graze and encourage them to leave grazed patches and graze elsewhere. This is because animals prefer to graze the fresh “green pick” that is produced after burning when soil moisture is present. In Central Australia, this is most commonly practiced on spinifex land types.

5.2.7.1 Evidence supporting this management action

Hazard reduction burns can provide for a containment of wildfire, thus reducing the expense of attempting to extinguish fires and minimising the loss of productive pastures (Edwards et al. 2008). Extensive wildfires in 2001-02 and 2010-12 burnt large areas of many Central Australian properties. A sample of 10 properties after the 2001-02 fires estimated that financial losses amounted to $850 000 (Allan and Tschirner 2009).

CSIRO studies conducted on open woodland and mulga country in the 1970s showed that low intensity fires during winter are best for hazard reduction and that palatable pasture plants were either maintained or increased after burning (Griffin and Friedel 1984b). Pasture recovery is difficult to predict because it depends on rainfall after burning. In the CSIRO studies, the quantity of standing pasture was suppressed for at least 12 months after burning, even in above-average rainfall years. Winter burns tended not to damage the dormant grass species and pasture species composition remained the same after burning. A review of fire studies in arid areas indicated that there should be no long-term adverse effects on yield or quality once enough rain has fallen (O’Reilly 2001b).

There is both experimental evidence (e.g. Andrew 1986) and a lot of practical experience to show that animals prefer to graze burnt areas that are regrowing compared with unburnt areas. In a burning trial at Mt Sanford Station in the Victoria River District (VRD) in the NT, burning appeared to alter the pattern of grazing in a rotationally burnt paddock. Cattle were attracted to burnt areas of the paddock, even when the burnt areas were a long way from water (Dyer et al. 2003). The attractiveness of the burnt areas was highest straight after burning, but declined within two years.

In 1995, a prescribed fire was used to burn two patches of hard spinifex (*Triodia basedowii*) country north-west of Alice Springs in order to improve pasture palatability. The following year was very dry and some wind erosion was beginning to occur. However, early in 1997 good rains produced abundant woollybutt (*Eragrostis eriopoda*) and other grasses. This growth was conservatively estimated to be 800 tonnes of grass in the 20 km² area. Woollybutt is quite coarse, but is preferable to hard spinifex and, in conjunction with supplementation, it provided some useful feed (O'Reilly 1998).

5.2.7.2 The implementation of this practice

Central Australian producers typically do not consider prescribed burning as a practice to improve productivity and profitability. Rather, prescribed burning is usually only seen as an option to prevent a loss of income in the event of wildfire or long term shrub increase (O'Reilly 2001b). Because rainfall is so unpredictable, most producers find it difficult to forego the immediate need for pasture in favour of burning for long-term land condition management. Both rain and wildfire may be unpredictable in their timing, but they are also both inevitable. Conducting small burns in drier years will enable producers to gain some valuable experience whilst accessing training and support from agencies such as Bushfires NT. This experience can help when dealing with wildfires, prescribed fires and implementing larger control burns as a result of wetter seasons (Bastin 1991a; O'Reilly 2001b). This is invaluable for learning to judge where fires will carry and where they will naturally stop (O'Reilly 2001b).

O'Reilly (2001b) recommended burning spinifex to reduce the risk of wildfire carrying into more productive country in good seasons. Spinifex can be burnt on a five to 15 year cycle and in drier years when the adjacent woodlands may have less fuel to carry a fire. Because graded firebreaks are largely ineffective in stopping wildfires, previously burnt spinifex and bare areas make the best firebreaks (O'Reilly 2001a).

Experience in the VRD indicates that rotational burning (burning 25% of the paddock every four to five years) can "re-set" the pasture and improve the evenness of grazing. The minimum area of a paddock to burn in the VRD is considered to be 25%. Any less than that and animals will concentrate on small burnt areas and may do more harm than good through overgrazing. The placement of fires in relation to water points and preferred parts of the paddock is also important. For example, in the Mt Sanford trial, burnt areas close to water were very heavily grazed and became degraded. Dyer et al. (2003) noted several factors that should be taken into account when rotational burning:

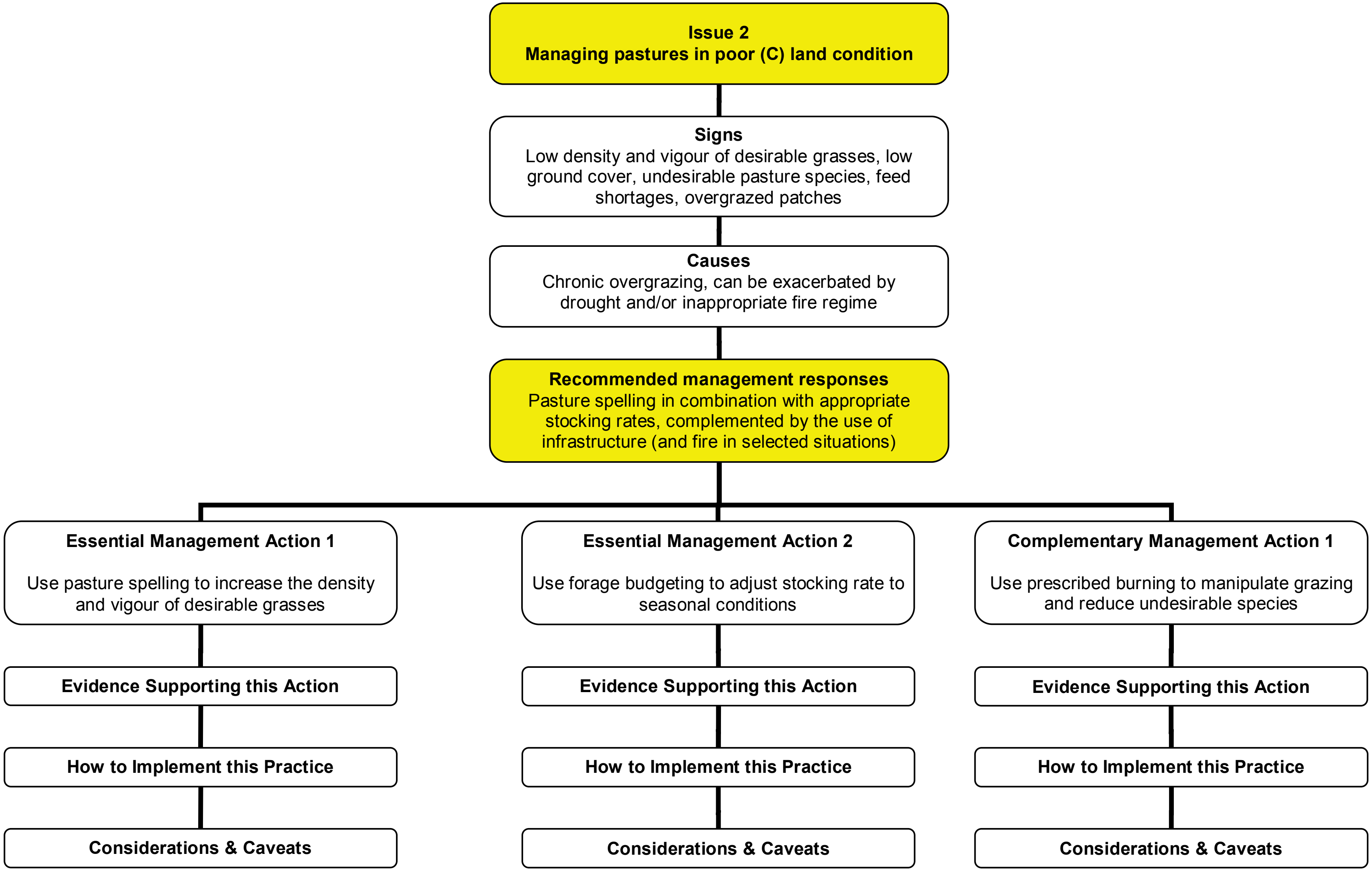
- Match the stocking rate to the new level of pasture available after burning.
- Do not re-burn areas for four to five years after burning.
- Be aware of the location of water points and preferred land types when burning.
- Do not burn areas that are already preferred by cattle as this can lead to excessive grazing after burning.
- Where possible, do not burn immediately adjacent to last year's burn as this can lead to overgrazing along the "edges".

5.2.7.3 Considerations/caveats

Conservative stocking rates will help ensure sufficient fuel loads for regular use of fire to control juvenile shrub populations (Bastin 1991a). After burning, stocking rates will need to be adjusted to account for the lower pasture availability in the paddock, especially if a large area is burnt. A forage budget is a useful tool for determining an appropriate number of stock in this instance. Feral animals and native herbivores also need to be kept off of the burnt country as much as possible.

Burning can increase or decrease the incidence of native woody species (see Section 5.4) and exotic weeds. Advice on possible responses to fire can be sought from DPIF, Bushfires NT and the Weeds Branch and/or your local Landcare coordinator.

This section of the guide has provided information on how to maintain land in good condition. The next section outlines practices to improve land in poor condition.


Issue 2
Managing pastures in poor (C) land condition
Signs
Low density and vigour of desirable grasses, low ground cover, undesirable pasture species, feed shortages, overgrazed patches
Causes
Chronic overgrazing, can be exacerbated by drought and/or inappropriate fire regime
Recommended management responses
Pasture spelling in combination with appropriate stocking rates, complemented by the use of infrastructure (and fire in selected situations)
Essential Management Action 1
Use pasture spelling to increase the density and vigour of desirable grasses
Evidence Supporting this Action
How to Implement this Practice
Considerations & Caveats
Essential Management Action 2
Use forage budgeting to adjust stocking rate to seasonal conditions
Evidence Supporting this Action
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Considerations & Caveats
Complementary Management Action 1
Use prescribed burning to manipulate grazing and reduce undesirable species
Evidence Supporting this Action
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5.3 ISSUE 2: MANAGING PASTURES IN POOR (C) LAND CONDITION

Section 5.2 covered the situation where a paddock or property is in good overall condition. This section deals with pastures that have deteriorated and the paddock or property is now mostly in poor condition. Note that land condition issues related to woody vegetation thickening are covered in Section 5.5.

NT Pastoral Land Board figures indicate that about 70% (n=50) of Tier 1 monitoring sites in the Northern Alice Springs pastoral district and about 84% (n=54) of Tier 1 monitoring sites in the Southern Alice Springs pastoral district were in fair to poor land condition in 2007-08 (Pastoral Land Board 2010a). In 2008-09, the Plenty pastoral district was reported to have about 87% (n=132) of Tier 1 monitoring sites in fair to poor condition (Pastoral Land Board 2010b).

The dilemma for producers with land in C condition is how to manage stocking rates to minimise periods of feed shortage while using pasture spelling (and sometimes fire) to improve land condition and productivity.

5.3.1 Signs

Most of the paddock or particular parts of the paddock (e.g. preferred land type/s) are in C land condition. A common scenario for a paddock in C condition is that the amount of useful pasture growth is low, but there are still some palatable, productive and preferred grasses. In Central Australia, these are usually perennial species but also include desirable annual species, many of which are capable of perenniating under good seasonal conditions. In C condition country, the valued grasses tend to be small, widely-spaced and have low vigour. Less palatable species are common, ground cover is generally poor and there is deteriorating soil surface condition, with some erosion and significant loss of moisture through run-off. In some cases, there is a high proportion of undesirable species, such as unpalatable perennial grasses and forbs. Friedel (1981) found that in wet years, the total biomass may not differ much between different land condition classes; however, species composition can be markedly different. Although highly nutritious pasture may be available for short periods after rain on C condition land, feed shortages can develop quickly in dry periods as the species present are only short-lived and individual plants have low bulk and vigour (Reu 2000).

Accurately assessing land condition in some parts of Central Australia can be difficult because the land condition decline was initiated many decades ago. In the early 1960s, Chippendale (1963) noted that in many areas, understorey vegetation was changing from predominantly perennial to annual species. For many current land managers, their experience may be that a particular land type or area has only ever grown annual species when in fact it has potentially greater productivity.

5.3.2 Causes

The primary cause of poor land condition is usually chronic and continuing overgrazing, which may be exacerbated by drought and/or intense wildfire events. Frequent and severe defoliation has deleterious effects on both individual plants by reducing their vigour, and on soils and pastures by reducing land condition. This is expressed as lower cover, more bare ground, lower infiltration and more run-off, accelerated erosion, altered botanical composition and increased patchiness. Drought and intense wildfire can sometimes magnify the stress on already weakened pastures, triggering a rapid land condition decline.

Palatable productive grasses are typically preferentially grazed within the pasture. If left unchecked, this can lead to a reduction in their size, vigour and eventual death. Under continuous grazing, seed production of these grasses may be prevented and recruitment of new grass seedlings can be minimal.

With the decline of these preferred grasses, other plants which have strategies to survive the grazing pressure tend to increase. These may be quick-growing, short-lived and prolific seeding species, such as button grass (*Dactyloctenium radulans*) or species with unpalatable traits that livestock avoid, such as wiregrasses (*Aristida* spp.) and copper burrs (*Sclerolaena* spp.). Unpalatable traits may include tough leaf blades and stems, chemical deterrents or prickles and spines.

The management questions that arise for pastures in C land condition are:

a. What combination of stocking rate and pasture spelling will minimise feed shortages and improve land condition?

b. Could infrastructure development improve the even-ness of use of pastures and spread the grazing pressure?

c. Does prescribed burning have a role in improving pasture composition and the vigour of preferred species on C condition land?

5.3.3 Management responses: use pasture spelling in combination with appropriate stocking rates, complemented by the use of infrastructure (and fire in highly selected situations)

The main objectives in this situation are to encourage the palatable and productive grasses to increase in the pasture and minimise the loss of soil and moisture in run-off. Experimental and anecdotal evidence suggests that the most effective actions will be pasture spelling combined with stocking rate management. 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 not usually a recommended action unless a particular species is known to be significantly encouraged by fire or you wish to alter grazing patterns to benefit particular species or areas of the paddock. In many cases, fire will actually exacerbate poor land condition by killing annual species, removing organic matter and ground cover and increasing grazing pressure on preferred species. The lack of perennial grass tussocks protecting the soil leaves it particularly vulnerable to erosion following the removal of ground cover by fire. Where a thickening of woody shrubs is causing land condition decline, fire is often recommended and this is discussed in Section 5.5.

5.3.4 Essential management action 1: use pasture spelling to increase the density and vigour of palatable and productive grasses

A general recommendation for improving pasture condition is to have a planned but flexible regime to spell target paddocks for the whole summer growing season commencing from the first rain event sufficient to initiate new growth (see Section 5.2.6.1 for the definition of growth event). Spelling regimes can be described by their timing, duration and frequency or number of rest periods. In effect, a spelling regime is applying a number of growing season rest days over a period of years. This raises questions about how the stage of the growing season, duration of rest periods and frequency influence the effectiveness of each rest day applied. Data on these questions is very limited but some clues can be derived from completed grazing and exclosure trial work and bio-economic modelling (see below).

5.3.4.1 Evidence supporting this management action

Pasture spelling has been widely recommended across many regions, though often with little local data on which to base cost-effective strategies. The existing experimental data from a limited number of regions indicates that spelling during the summer ‘wet season’ and particularly during the early growing season when grasses are most susceptible to heavy defoliation, is important for managing palatable and productive grasses (Ash and McIvor 1998; Hunt et al. 2010). Unlike farther north, Central Australia does not have a defined ‘wet season’ per se and growth events can occur at any time of the year (Slatyer 1962). That said, the most productive time for grass growth in Central Australia tends to be in the warmer months between October and March.

Perennial grasses need time to grow a leaf canopy (often from low root reserves), re-build root reserves to survive the following dry period and initiate future growth, and produce seed. Seedlings require sufficient time to grow and store root reserves to survive dry periods. Annual grasses need to germinate, develop root systems and leaf structures, and produce abundant seed. Many productive grasses in Central Australia are not strictly annual and will persist and reshoot in good seasons if allowed to become robust enough.

Consequently, longer rest periods may have advantages over shorter periods in terms of accumulated benefit in Central Australia.

The required frequency of spelling or number of rest 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; see Section 5.4), stocking rates when grazed and growing conditions experienced during the rest period. Establishment of seedlings from the seed set during an earlier rest period may be enhanced by a subsequent rest period. In northern Australia, wet season spells occurring once every three to four years are often recommended; however, model analysis of a similar strategy in the Alice Springs region resulted in little benefit. Due to the extremely variable seasonal and annual rainfall, more frequent spelling is recommended for Central Australia in order to maximise the likelihood of pastures receiving sufficient rainfall for land condition recovery whilst they are being spelled.

Using the GRASP model, a wide range of spelling strategies have been assessed for Central Australia. These include frequencies ranging from one year in four, through to every year and durations of two, three or six months. Spelling *every* year for six months was found to be the most effective for promoting land condition recovery. The modelling also showed that for the *same average annual* stocking rate, spelling for half the time (i.e. doubling the stocking rate during the graze period) was more effective in promoting land condition recovery than continuous stocking at half the stocking rate. In effect, this approach applies the same number of grazing days across a year, but the spelling provides benefits for land condition recovery.

Based on this preliminary model output, a spelling regime was devised that was practical to implement, relatively simple to model and potentially effective for the Alice Springs region. The performance of this spelling regime was tested using GRASP and included a comparison with a continuously-grazed paddock with the same effective stocking rate. For the spelling regime, two sets of paired paddocks (2 x 2 = 4 paddocks) were spelled for a full year in alternating years (Figure 7). All paddocks were in C condition at the start of the simulation and were paired on the basis that they had a similar carrying capacity. When a paddock was being spelled, all the cattle from that paddock were carried in the other paddock. Because the spelled paddocks have one year with double the normal stocking rate and one year with no stock, the average stocking rate for spelled paddocks is equal to the continuously-grazed (no spell) paddocks.

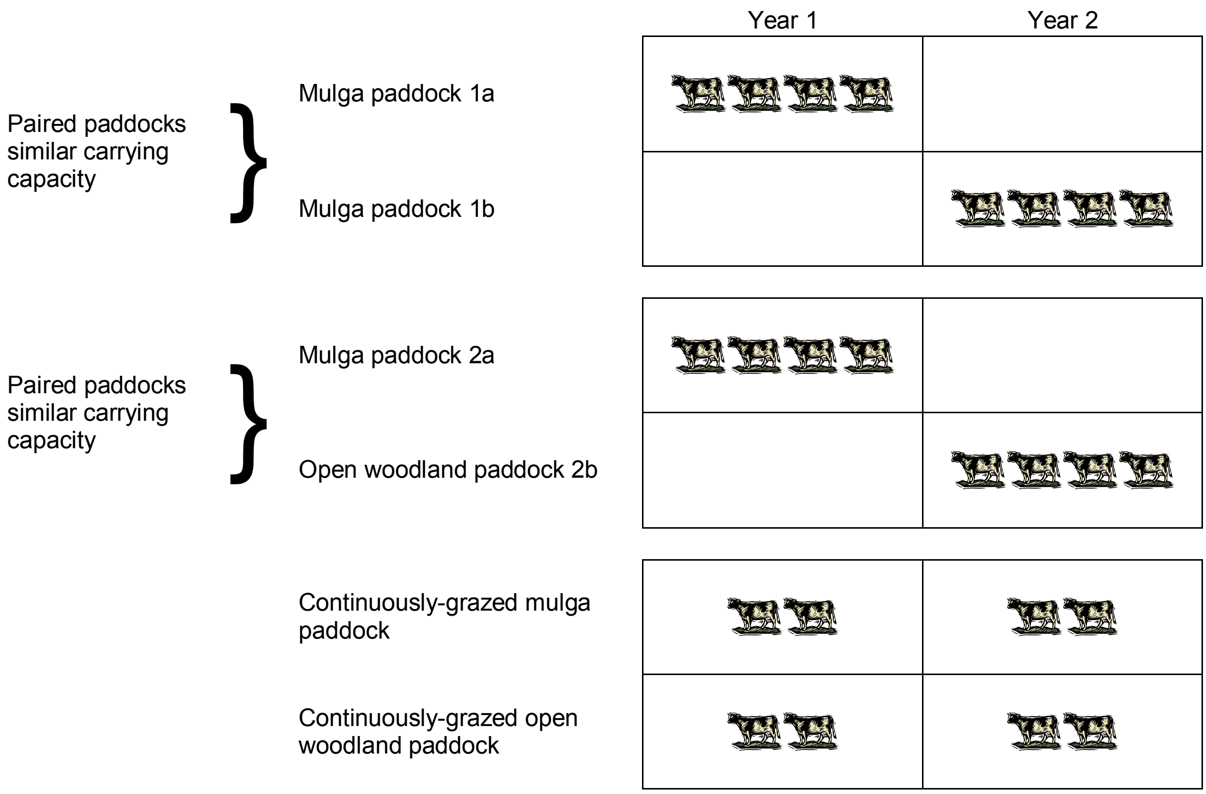


Figure 7. Diagrammatic representation of the spelling strategy. Each of the paired paddocks is grazed for one year carrying all the stock that could be safely carried in both paddocks and then spelled the following year. The continuously-grazed paddocks are stocked at the safe carrying capacity every year without spelling.

Figure 8 shows the effect of spelling when land is in C condition and also highlights the importance of matching demand to feed on offer, particularly in the dry years in order to maintain land condition. Stocking rates were fixed in all paddocks until land condition recovered to A condition. The safe stocking rate for the mulga paddocks was 0.8 AE/km^2 and 1 AE/km^2 for the open woodland paddocks. In the paired mulga paddocks (1a and 1b), the rate of recovery was quite different from 1987 onwards. This can be attributed to paddock 1a being spelled and paddock 1b being grazed during the extremely dry year of 1985. Essentially, paddock 1b was overstocked during a dry year when susceptibility to degradation was higher. For the other pair (mulga paddock 2a and open woodland paddock 2b), the average stocking rate was 0.9 AE/km^2 resulting in heavier than recommended grazing in the mulga paddock and lighter than recommended grazing in the open woodland paddock. Nevertheless, continuation of the spelling strategy allowed land condition to improve in the paddocks that were being spelled during 1985 (the open woodland paddock reached A condition in 1997 and mulga paddock 1a in 2001). Following the above-average season in 2001, the other mulga paddocks (1b and 2a) markedly improved in land condition whereas the continuously-grazed paddocks never improved in land condition and were still in C condition at the end of the simulation.

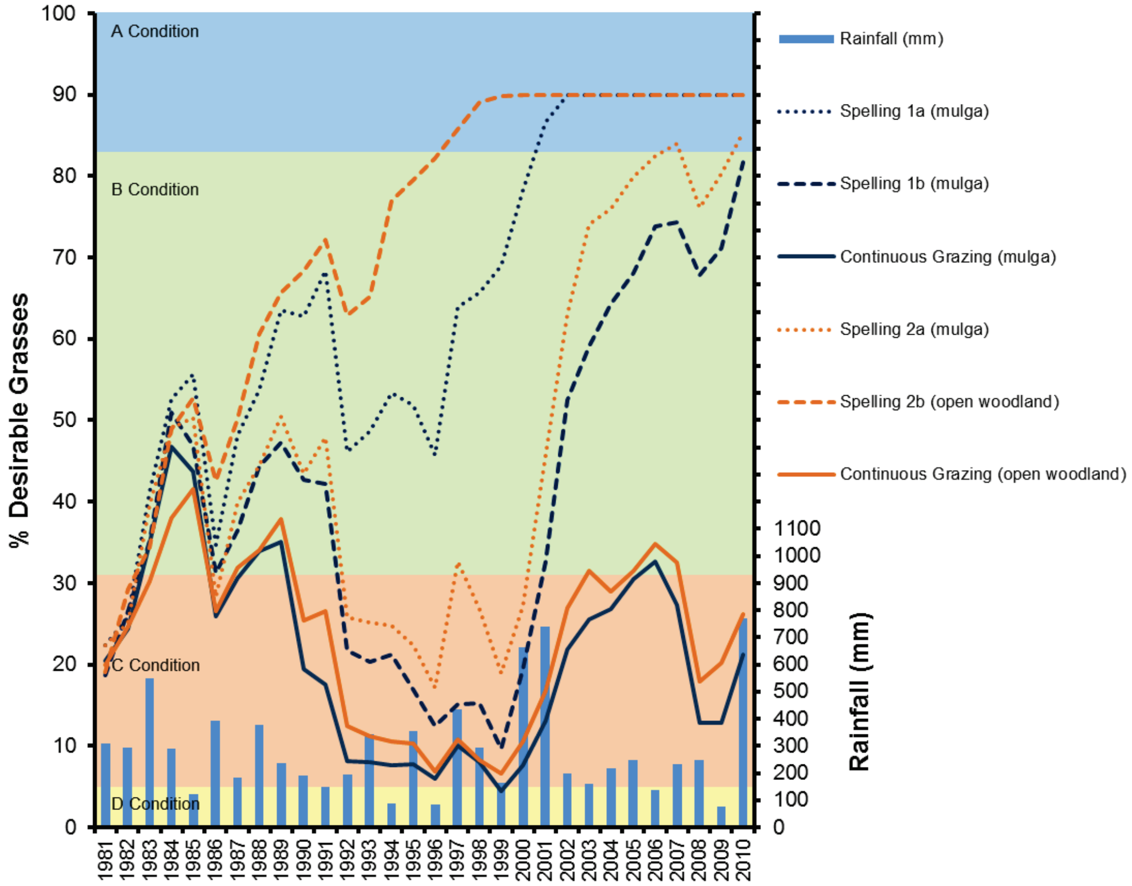


Figure 8. The effect of alternating year-long spelling with year-long grazing on mulga (paddocks 1a, 1b and 2a) and open woodland (paddock 2b) paddocks. The safe stocking rate for the mulga paddocks was 0.8 AE/km^2 and for the open woodland paddock 1 AE/km^2. For the mulga paddock paired with the open woodland paddock, the average stocking rate was 0.9 AE/km^2, resulting in higher than recommended utilisation in the mulga paddock and lower than recommended utilisation in the open woodland paddock. Land condition in the open woodland paddock improved to A condition in 1997 and stocking rate was subsequently increased to 1.9 AE/km^2. Mulga paddock 1a reached A condition in 2001 and the stocking rate was increased to 1.2 AEkm^2. Percentages desirable grasses in the pasture are used as a proxy for land condition. Note that the rainfall shown is from 1 January to 31 December each year whereas the model output year is 1 May to 30 April.

Producers often ask how long it will take to see a real benefit from implementing a spelling strategy. This depends on the seasons experienced. In the simulations described above, it took seven years before any real difference in pasture growth emerged between spelled paddocks and continuously-grazed paddocks, and this was only for the two paddocks that were ungrazed during the very dry year of 1985 (Figure 9). The other two paddocks in the spelling strategy did not show higher pasture growths until the very wet year of 2001. Thus, it can take many years to see improvements in pasture growth and land condition; short-term results should not be expected. Very high rainfall years also appear to be crucial for land condition recovery. This is confirmed by the experience of producers in the region (e.g. Walsh 2009a, e).

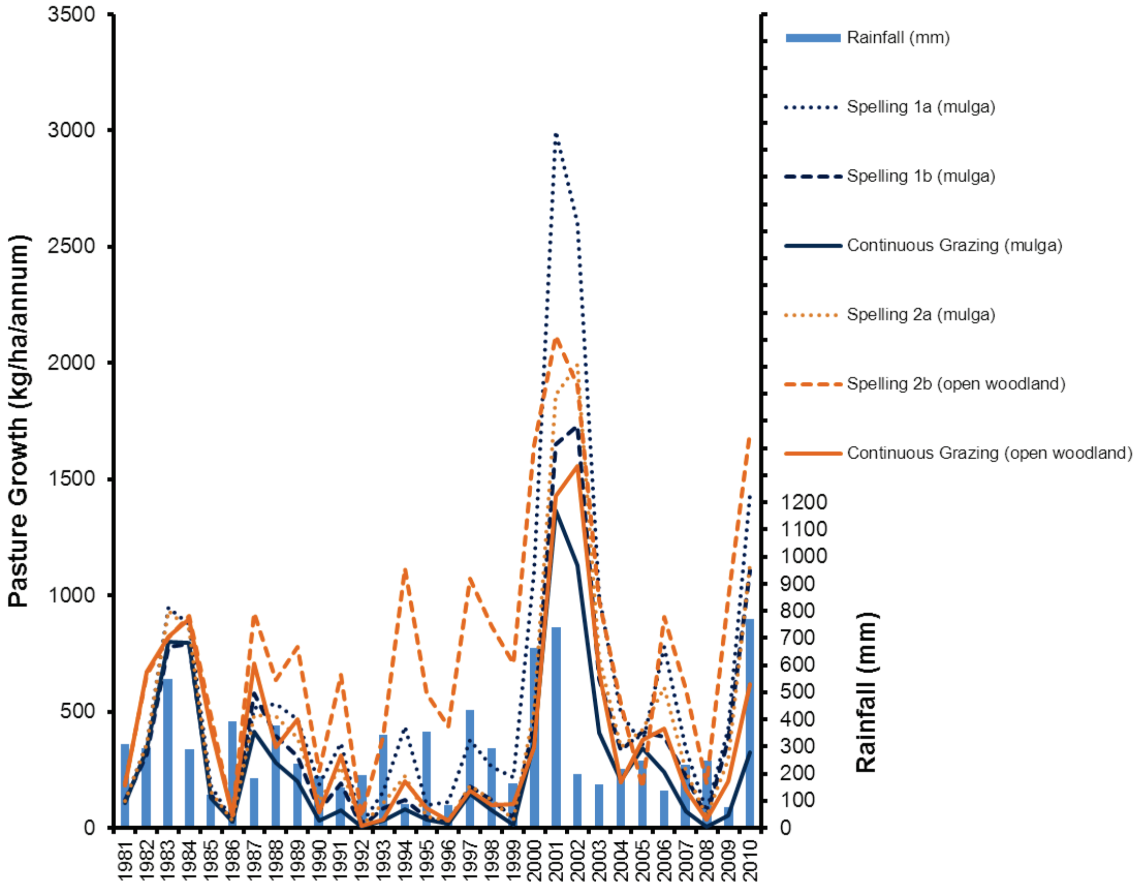


Figure 9. GRASP pasture growth simulation of a year-long spell every second year achieved via a paired paddock rotation system where cattle from both paddocks are grazed in one paddock while the other is being spelled. Paddocks 1a and 1b (mulga land type) are paired and paddocks 2a (mulga) and 2b (open woodland) are paired. Two continuously-grazed paddocks are included for comparison. The paddocks ungrazed in the dry year of 1985 (1a and 2b) showed higher pasture growth from 1986 onwards. The other spelled paddocks (which were grazed in the dry year of 1985) only showed higher pasture growth after the very wet period in 2000-01. Note that the rainfall shown is from 1 January to 31 December each year whereas the model output year is 1 May to 30 April.

Initially, the spelled paddocks in the model simulation had lower LWG/hd than the continuously-grazed paddocks (Figure 10). This was because the spelled paddocks had double the stocking rates when they were being grazed compared with the continuously-grazed paddocks. Until land condition and growth improved, the higher stocking rates during grazing episodes had a dampening effect on LWG/hd in the paired spelling paddocks. The impact of isolated very dry years is also apparent in the results. For the two paddocks *not* grazed during the dry year (1985) LWG/hd became more consistent and higher compared with the continuously-grazed paddocks within about 11 years. The two paddocks that were grazed during 1985 took much longer to show improvements in LWG/hd. This highlights a number of points. Firstly, it is not necessary to wait until very good seasons before implementing a spelling regime as benefits can be achieved in more average years, even though the maximum benefits might not be realised until the really wet years. Secondly, as land condition improves, LWG/hd becomes much more stable and this is of great advantage to maintaining production values through the dry years. This supports the experience of producers in Central Australia who routinely practise good spelling and stocking rate management (Walsh 2009b, 2009c, 2009d, 2009e).

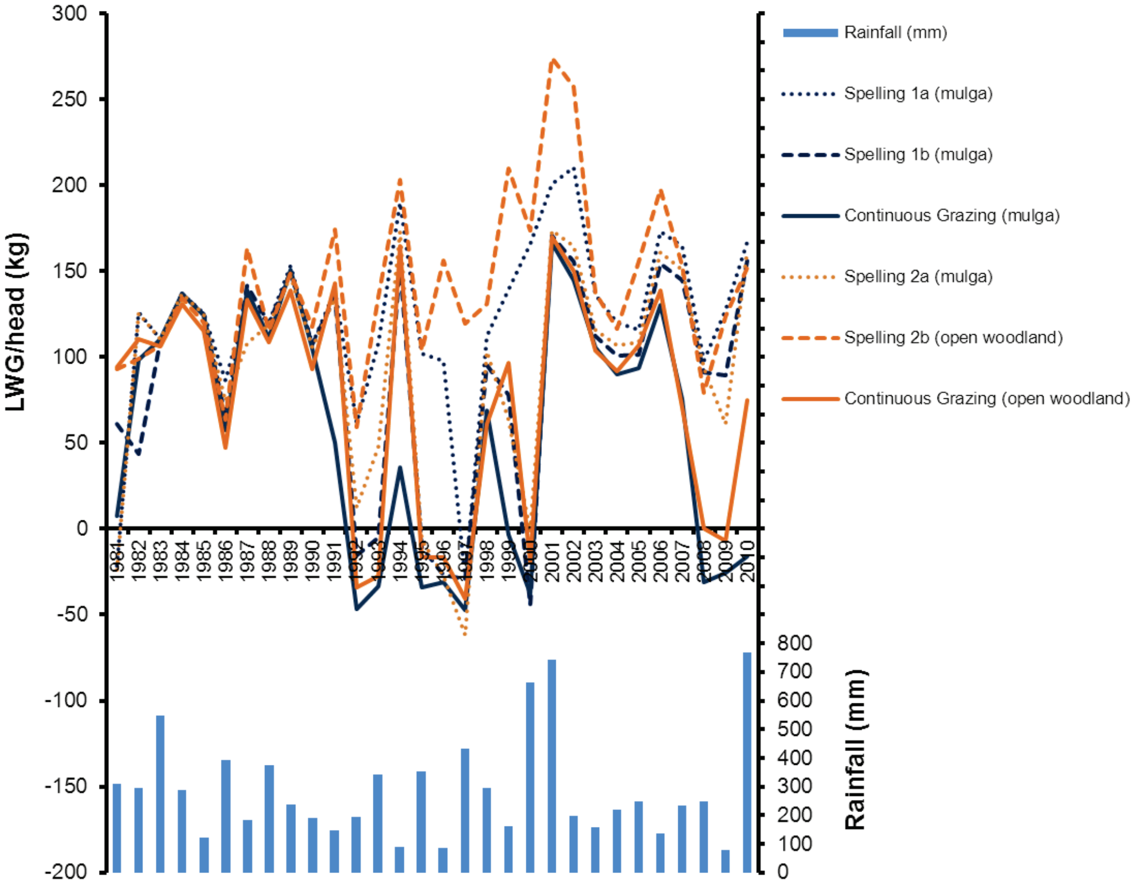


Figure 10. GRASP live weight gain per head simulation of a year-long spell every second year achieved via a paired paddock rotation system where cattle from both paddocks are grazed in one paddock while the other is being spelled. Paddocks 1a and 1b (mulga land type) are paired and paddocks 2a (mulga) and 2b (open woodland) are paired. Two continuously-grazed paddocks are included for comparison. Initially, paddocks in the spelling strategy had lower LWG/hd than continuously-grazed paddocks because all the animals from a spelled paddock went into its paired grazed paddock, resulting in heavy grazing and reduced forage availability for each animal. Once land condition and pasture growth improved in the spelling strategy, so did LWG/hd. Note that the rainfall shown is from 1 January to 31 December each year whereas the model output year is 1 May to 30 April.

In terms of LWG/ha, it was ten years before the spelled and continuously- grazed scenarios diverged (Figure 11). LWG/ha increased for the rotationally-grazed paddocks due to the spelling, then further increased when stocking rates were raised in paddocks 1a and 2b once they reached A condition. It is worth noting that even during the dry years of the late 2000s, LWG/ha was always above zero in all paddocks that had received some spelling.

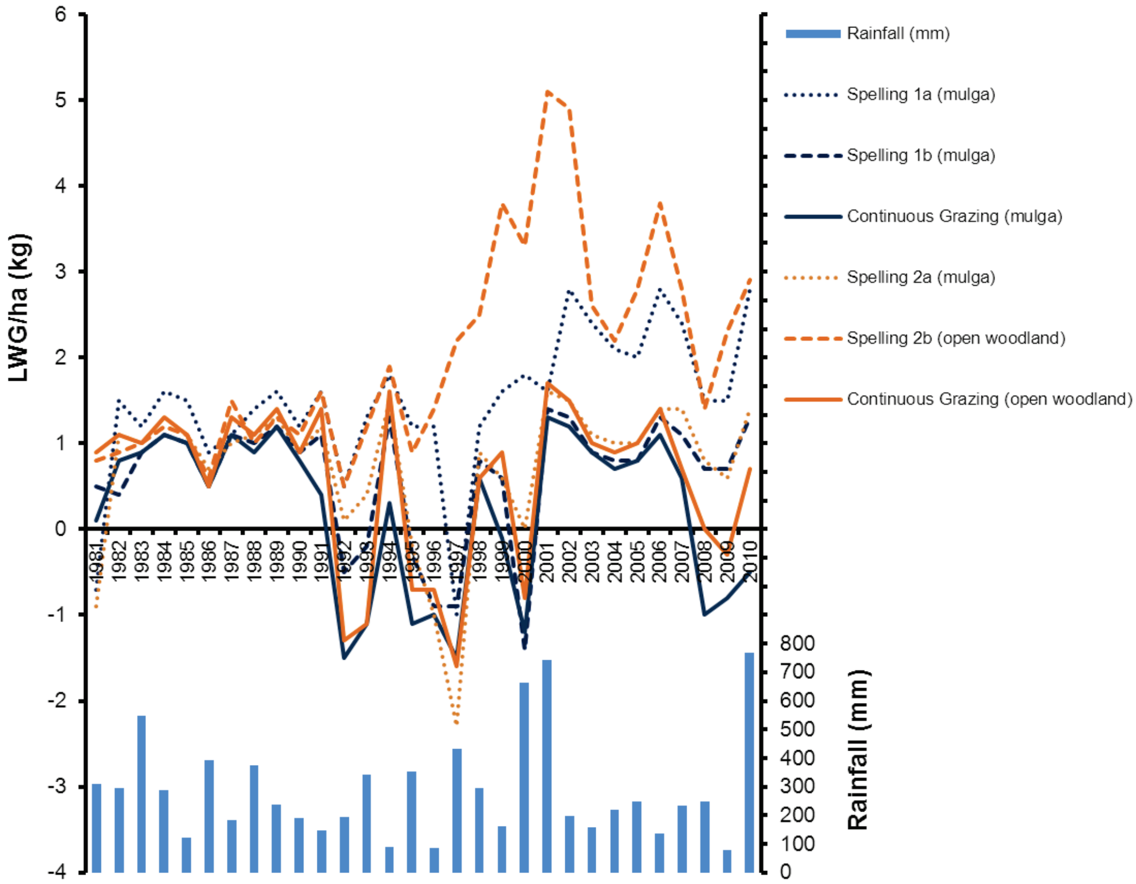


Figure 11. GRASP live-weight gain per hectare simulation of a year-long spell every second year achieved via a paired paddock rotation system where cattle from both paddocks are grazed in one paddock while the other is being spelled. Paddocks 1a and 1b (mulga land type) are paired and paddocks 2a (mulga) and 2b (open woodland) are paired. Two continuously-grazed paddocks are included for comparison. It took ten years before the LWG/ha of the spelled paddocks diverged from the continuously-grazed paddocks. Once land condition had improved in the spelled paddocks, the stocking rate was increased and therefore LWG/ha also increased. The improvement in land condition of all the spelled paddocks meant that LWG/ha remained above zero for them during the drier years of the late 2000s. Note that the rainfall shown is from 1 January to 31 December each year whereas the model output year is 1 May to 30 April.

Spelling for a whole year every second year with double the normal stocking rate between spells improved average annual profit by around 34% (Table 9).

Table 9. Profit measures for the Alice Springs representative property with and without spelling (1981 to 2010). Although not every paddock on the property was spelled, when spelling was implemented in some paddocks, the average profit was higher compared with the same property with no spelling. It is also important to note that the number of years where a loss was made was lower when spelling was implemented. This was because an improvement in land condition in the spelled paddocks meant that positive live-weight gain was achievable even in the dry periods.

Profit	Continuous grazing	With spelling
Average	$180 225	$273 280
Minimum	-$116 880	-$194 479
Maximum	$508 305	$828 043
No. of negative years	3	2
Net present value	$3 124 239	$4 362 744

The simulations indicate that the spelling regime tested is economically viable and practical to implement with animals only moving between paired paddocks once a year. Because stock from both of the paired paddocks were placed in the grazed paddock while the other was spelled, agistment was not required and animal production was maintained. However, change on the ground was very slow, with little change in animal production between spelled and unspelled paddocks in the first 10 years of implementation.

In these simulations, the stocking rate that kept continuously-grazed paddocks in C condition allowed gradual land condition recovery when spelling was added (but with the same average stocking rate). This demonstrates that absolute stock numbers may not always need to be reduced in order to achieve spelling and land condition recovery. However, if stocking rates are too high, land condition will never recover, even with spelling. Hence forage budgeting is an integral component of successful spelling to achieve land condition recovery.

This method of spelling does not require similar sized or similar land type paddocks to be paired, but it does require that paired paddocks have a similar carrying capacity otherwise the paddock with lower carrying capacity will potentially be overgrazed between spells. In this simulation, paddocks 1a and 1b were very similar in size, land type and carrying capacity, but Paddocks 2a and 2b were slightly different. The open woodland paddock (Paddock 2b) had a higher safe stocking rate than its paired mulga paddock (Paddock 2a). The effect of this can be seen in the faster land condition recovery of the open woodland paddock, which was effectively being slightly understocked between spells, compared with the mulga paddock, which was being slightly overstocked between spells and took an extra 15 years to recover to A condition. Where the carrying capacity of paired paddocks cannot be ideally matched, these results suggest that both paddocks should be stocked at the lower carrying capacity. In the simulation described above, this would have decreased the time taken for the mulga paddock to reach A condition, which would have allowed a stocking rate increase sooner.

Land condition recovery could be fast-tracked by monitoring the utilisation of paddocks between spells and adjusting stocking rates so that paddocks are not overgrazed between spells.This may dampen production initially due to lower average stocking rates in spelled paddocks, but recovery of land condition and productivity would be faster.

In an example of a local approach to spelling, a four-paddock rotation has been implemented on Old Man Plains Research Station near Alice Springs. The objective of the rotation strategy is to maintain or improve land condition by resting pastures during the growing season. The strategy allows for approximately nine months annual spelling in the paddocks dominated by oatgrass (*Enneapogon* spp.) pastures and 18 months spelling in the mulga paddocks (Materne 2010b). Land condition change is slow in the arid zone (Chilcott et al. 2005) and even though observations suggest that previously bare areas are starting to be recolonised with pasture species, it is too early to say if this is a result of the grazing strategy or simply matching stocking rate to feed on offer. An important outcome has been that during below-average rainfall years, the strategy provided carryover feed for three to six months longer than a nearby continuously-grazed paddock, which allowed the herd to be retained until it rained.

5.3.4.2 The implementation of this practice

Several producers in Central Australia use spelling as part of their grazing management either in the form of regular, planned rotations or more opportunistic events. Decisions to move stock are based on observations of seasonal conditions, species present, ground cover, time of year, market demands, presence of perennial grass butts, grass biomass, rainfall, locations of cattle and cattle condition. In order for timely, reliable decisions to be made, pastoralists cited the need to keep accurate, up-to-date records on herd performance and land condition. Several properties are considering doing further subdivision of paddocks to provide more options for spelling, which indicates they are finding benefits from their current strategies (Walsh 2009a, 2009b, 2009d, 2009e; Materne 2010a).

Grasses are highly susceptible to grazing within the first six to eight weeks of a growth event (Ash et al. 1997), so stock should be removed prior to (or as soon as possible after) rain in order to initiate a good response to the spelling period. However, a full summer spell may be more practical to manage and perhaps more cost-effective in some situations. Pasture responses to spelling are much poorer in below-average years compared with average or good years, so the cost-effectiveness of spelling is likely to be greater in better years.

Many producers who already practise spelling, are adamant that spelling regimes need to be applied flexibly rather than rigidly so that seasonal conditions can be taken into account. Spelling achieves the best results in above-average rainfall seasons so producers may take the opportunity to spell more parts of the property at these times. In these seasons, cattle from the areas to be spelled can be retained and put into other paddocks because the increased feed supply is able to support them. Or, if a paddock happens to receive exceptional rain in the course of a planned rotation and looks to do so again, producers might consider altering the rotation so that a poorer condition paddock gets the spell instead. On a practical level, rain can hinder mustering, particularly when there is plenty of surface water available and sometimes financial or seasonal constraints mean that a paddock earmarked for spelling is required for production. Other options for minimising adverse outcomes in a rotational spelling regime are to reduce overall cattle numbers before initiating the spelling, or distributing the cattle from the spelled paddock to other paddocks on the basis of their relative land condition and forage supply (rather than just spreading them evenly across the other paddocks).

Further ideas for implementing spelling strategies can be found in Section 5.2.6.

5.3.4.3 Considerations/caveats

See Section 5.2.6.3.

5.3.5 Essential management action 2: use forage budgeting to adjust stocking rate to seasonal conditions

Minimal gains will be made with spelling if stocking rates following the rest period are not matched to feed supply and ongoing overgrazing occurs. Section 5.2 describes how to match animal demand and pasture supply.

5.3.6 Complementary management action 1: use prescribed burning to manipulate grazing patterns and reduce undesirable pasture species

Fire is considered to be a supplementary tool for improving land condition and is less important than spelling and stocking rate management. Fire can be used to attract cattle away from areas to be spelled because animals prefer to graze recently-burnt areas in preference to non-burnt areas, due to the higher quality pasture. Fire can also be used to remove dry, rank pasture from under-grazed patches and “re-set” patches that have been overgrazed (although in Central Australia this may only be effective following high rainfall seasons or in land types that carry a lot of buffel grass).

5.3.6.1 Evidence supporting this management action

Fire can be used to spell other parts of paddocks as animals prefer to graze recently-burnt areas in preference to non-burnt areas. This will allow some spelling of the non-burnt areas and has been effective under experimental conditions in 5 km^2 paddocks (Dyer et al. 2003). Its effectiveness under commercial conditions is unknown. 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 gained 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. This can improve the even-ness of 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 rest.

Fire can also be used to manipulate undesirable species in the pasture. The most effective action will depend on the undesirable species being targeted and whether or not they are sensitive to fire regimes. Griffin and Friedel (1984a) found that the season in which the burn occurred had an important influence on subsequent pasture composition. Winter fires damaged the forbs but not the grasses, which were dormant at the time of burning. Alternatively, summer fires damaged the grasses and favoured the subsequent winter growing forbs. This suggests that there is some scope for influencing pasture composition using appropriately timed fires. Griffin and Friedel (1984a) also suggested that when burning reduced the canopy cover of mulga, more light was able to reach the ground to encourage germination and growth of pasture species. In their study, palatable grass biomass in the burnt areas exceeded that in the unburnt treatments within 12 months of a winter burn in open woodland and mulga land types. Following a summer fire, it took two years before the palatable grass biomass in the open woodland exceeded that of the winter burn while in the mulga community, biomass exceeded that of the unburnt plots but not the winter-burnt treatment. The positive pasture response following the fires in their experiment was probably facilitated by above-average rainfall years. Post-fire pasture response is ultimately dependent on soil moisture levels and Griffin and Friedel (1984a) suggested that burning practices might be best applied after periods of above-average rainfall. Anecdotal reports from wildfires in Central Australia in 2011 indicated that sufficient soil moisture was available to initiate reasonable growth of perennial species that had become rank and unpalatable, thus confirming that seasonal conditions are a major factor in the success of burning.

5.3.6.2 The implementation of this practice

The implementation of a fire regime will require planning to ensure adequate fuel is available which may mean adjusting stocking rates or undertaking spelling to preserve fuel, followed by conservative stocking rates or spelling in the post-fire period to encourage the recovery of desirable pasture species. Additional infrastructure may be useful for enabling smaller areas to be burnt.

Producers have to determine the fire regime required to manage the target species (a fire regime over many years may be required, not just a single fire). However, an important consideration prior to burning is to ensure there are adequate fuel loads and appropriate weather conditions to carry the fire. Land type, soil type and land condition will influence the capacity for effective fires (see Section 5.4.4.2).

Utilising fuel accumulated in above-average seasons will minimise the opportunity cost of spelling prior to burning. Land managers should aim to address two or more ‘purposes’ with the same fire regime (e.g. manage a woody plant and an unpalatable grass whilst improving the even-ness of grazing and pasture quality). The risk of a below-average season must also be considered and appropriate strategies put in place if the season following burning has low rainfall.

5.3.6.3 Considerations/caveats

There are some important considerations when contemplating the use of fire to improve C land condition. The first is that there is a high risk that fire will further damage already weakened pasture, reduce cover to low levels and leave soils exposed to erosion. High fire frequency can lead to the loss of fire-sensitive species and prevent preferred pasture species from replenishing their root and seed reserves. Prescribed burning also comes at a cost to animal production. Costs will be associated with any spelling of pastures that is required to build up fuel loads. 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 fire. Grazing in the immediate post-fire period hinders the recovery of desirable pasture species. In particular, it is ideal that palatable grasses are allowed to set seed in the post-fire period and this may require destocking or, at least, very low stocking rates. If pre- or post-fire destocking is necessary, forage must be available for livestock on other parts of the property or else they will have to be agisted or sold.

Fire (particularly intense summer burns) can promote mass germination of some woody plants, notably acacia species, such as mulga. 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. A second fire may be required to kill the young plants. Conducting a second burn before the recruits set seed can also reduce the seed banks of acacias.

Issue 3

Rehabilitating pastures in D land condition

Signs
Low ground cover, undesirable pasture species, feed shortages, severe erosion, disrupted drainage patterns, abundant woody shrub thickening.

Causes
Chronic overgrazing, can be exacerbated by fire regimes and/or drought. Disruption of drainage patterns.

Recommended management responses
Restore processes e.g. water flow/ponding, nutrient cycling. Apply appropriate stocking rates and pasture spelling. Use fire to modify woody vegetation.

Essential Management Action 1

Use rehabilitation techniques (e.g. ponding banks) to restore landscape function.

Evidence Supporting this Action

How to Implement this Practice

Considerations & Caveats

Essential Management Action 2

Use pasture spelling and appropriate stocking rates to allow pastures to regenerate.

Evidence Supporting this Action

How to Implement this Practice

Considerations & Caveats

Essential Management Action 3

Use prescribed burning to reduce woody vegetation density.

Evidence Supporting this Action

How to Implement this Practice

Considerations & Caveats

5.4 ISSUE 3: REHABILITATING PASTURES IN D LAND CONDITION

Section 5.3 covered the situation where pastures have deteriorated and the landscape is mostly in poor (C) land condition but can be reclaimed using spelling and appropriate stocking rates. This section deals with landscapes where land condition has declined to a point where grazing management changes alone will not restore productivity. This arises when landscape function processes (primarily nutrient and water retention abilities) have broken down (Ludwig et al. 2007). Restoration of these areas may require significant intervention, such as earthmoving machinery, reseeding, landscape modification and weed control together with subsequent appropriate grazing management, such as pasture spelling and low stocking rates.

Most land managers in Central Australia recognise that declining land condition is having an enormous impact on productivity and that it may take considerable resources and time to reverse this trend. Rehabilitating landscapes is important because without intervention, these degraded areas can inhibit the recovery of adjacent C condition pastures that might otherwise be retrievable using appropriate stocking rates and spelling. Furthermore, until degradation is halted, it is likely to continue causing further land condition decline in areas that are currently in reasonable condition.

5.4.1 Signs

Land in need of restoration will have one or more of the following characteristics. General pasture cover is usually very low, even after significant rainfall events, as most of the water runs off, or has been diverted to other parts of the landscape. Following small rainfall events, there may be no pasture growth whatsoever. Competition from weeds or woody plants may also be restricting the potential for pasture growth. There may be no palatable, productive and preferred grasses remaining, or if present, they are rare. In some cases, there is a high proportion of undesirable species, such as unpalatable grasses and forbs. Severe erosion, such as gullies, sheet wash and scalding are often present. It is highly probable that a general disintegration of the natural drainage patterns has occurred (Pringle and Tinley 2003; Chilcott et al. 2005).

5.4.2 Causes

For the most part, land that has declined to very poor condition has suffered a significant disruption to natural surface drainage patterns and processes. To make the most of low rainfall, arid zone landscapes are composed of a complex network of run-on and run-off areas (Stafford Smith and Morton 1990). This means that the run-off from rainfall tends to concentrate in specific parts of the landscape. These areas tend to be more nutrient-rich than surrounding areas and this is where maximum plant growth occurs. For arid landscapes to be productive, they need to retain such resources as water and nutrients in close proximity to each other. Landscape function analysis is a measure of how well this is being achieved and describes the 'leakiness' of a landscape with regard to vital resources (Ludwig et al. 2007). Even though much of Central Australia appears flat, it often consists of very long, gentle slopes that drain by sheet flow. This sheet flow feeds run-on areas that range from small depressions to broad, shallow drainage floors and floodplains and wetlands. These drainage areas not only support the most abundant and nutritious pasture, they also green up quickly after rain. Serious declines in land condition are initiated when these run-on run-off processes are disrupted.

Disruption can occur due to poor development of infrastructure and overgrazing. Graded lines such as roads, fence-lines or pipelines can disrupt drainage patterns if they are poorly located or constructed. Run-off is often concentrated along these lines and the accumulated water flow becomes very erosive. When sheet flow is diverted, areas down-slope of graded lines can become artificially droughted, leading to a decline in pasture growth and ground cover. These bare soils then generate greater run-off and the degraded area continues to expand.

Overgrazing reduces the number of perennial grass butts which are vital for protecting the soil from erosion, particularly at the beginning of summer and during drought. When soil surfaces are left bare of vegetation, sheet flow increases in velocity and becomes more erosive. Run-on areas become filled with eroded, nutrient-poor sediment and as the soil surface becomes 'smoother' run-off increases even more. The subsequent increased volume of run-off exceeds the absorption capacity of the broad shallow drainage floors and deeply incised channels are created. The increased volume and velocity of water flow accelerates erosion along drainage channels, which become unstable and new gullies are formed, further concentrating and diverting water flow.

As drainage channels deepen and gullies are created, soil profiles become exposed, providing a large surface area for evaporation to occur. Subsequent lateral movement of water within the soil profile further dries the topsoil making it difficult for herbage to thrive. This sets up a negative spiral whereby ground cover declines further, run-off increases and erosion is accelerated.

Landscapes are stabilised by their "base level". This can be described as the slope where erosion occurs so slowly as to be nearly negligible. These areas will have a relatively uniform slope (e.g. a plain or a section of river) and any sudden changes of slope are identified by a nick point, such as a rock bar. If the nick point is raised or lowered (e.g. increased run-off erodes drainage lines) or an 'artificial' nick point is created (e.g. graded line) then the landscape will erode until the base level is again reached. Essentially, landscape stability and resistance to erosion are defined by soil, geology and the base level that limits water movement and therefore erosive energy. When an incision lowers this level (e.g. incised drainage, stock pad, graded line) erosion will occur. A relatively new approach to land assessment in Central Australia is the EMU (Ecosystem Management Understanding) process. Essentially, this process assesses the hydrological regime of a given landscape to identify where base level incision has occurred and where water is being lost from the system. The assessment identifies how adjacent landscapes are interconnected and therefore how the cause of an obvious problem (e.g. a gully, woodland thickening) can actually be the result of a breakdown in the hydrology of areas much farther up-slope or down-slope (Pringle and Tinley 2003).

A land condition decline also occurs when the base level *rises* as a result of increased sedimentation. An example of this might be when sediments from accelerated erosion are deposited in a low lying area or wetland (often at the terminus of a landscape) resulting in a decline in soil fertility or reduced flooding. Sometimes, piles of sediment can redirect water flow causing further disruption to the hydrology. Some areas become further degraded when the 'new' drainage pattern causes a concentration of run-off leading to incision and then a new process of base lowering.

Woody shrub thickening is often linked to disruption of the hydrological process. In some instances, where eroded deposits and extra water are deposited, woody shrubs can become prolific and out-compete the more desirable grasses and herbages. Shrubs are also capable of surviving in drier conditions than grasses (because they can access water at greater soil depths) and often form dense thickets adjacent to and within eroded areas.

Wind erosion can also play a significant role in the degradation of soil surfaces and therefore the ability for pasture to grow. Even in dry periods, the presence of perennial grass butts provides valuable protection against wind erosion. When perennial grass butts are lost through overgrazing or fire, wind erosion strips the nutrient-rich topsoil from less fertile subsoils, some of which will be lost from the system. Windblown hummocks tend to be unstable and can dry out quickly, therefore supporting minimal pasture.

The management questions that arise for land in need of restoration are:

a. What techniques will restore landscape processes?

b. What combination of stocking rate and pasture spelling will allow the pastures to regenerate?

c. Does prescribed burning have a role in reducing woody thickening in degraded landscapes?

5.4.3 Management responses: use rehabilitation techniques to restore landscape function processes, followed by appropriate stocking rates and pasture spelling. Use fire to control the density of woody species where appropriate

The primary objective is to restore natural water movement patterns and keep water in the landscape. This will often involve some mechanical intervention in the form of earthmoving machinery to construct banks for ponding or diverting water. Other techniques may include reinstating base levels using permanent or semi-permanent structures, such as logs, rock armouring or earth banks. Appropriate stocking rates and pasture spelling will be necessary in order to maximise ground cover.

Woody shrub thickening may be contributing to, or a result of, changed water regimes. Restoring the natural landscape processes is an important first step as it will help reduce the chances of the problem recurring. Restored drainage flows may cause some death amongst the thickened population. It may then be necessary to facilitate the build-up of fuel so that fire can be used to significantly reduce the population.

5.4.4 Essential management action 1: use rehabilitation techniques (e.g. ponding banks) to restore landscape function

Local experience confirms that spelling alone is not enough to recover highly degraded landscapes. For example, areas of calcareous grassland that had been heavily grazed and droughted showed evidence of wind-sorted accumulation of sandy bands interspersed with wide, hard setting scalded areas (Friedel 1993). After 10 years of continuous spelling, there was some improvement in the palatable shrub cover but no improvement in the pasture or the soil surface conditions. Similarly, on a site north of Alice Springs, 25 years of spelling on hard-setting scalded country did little to restore the productivity of the once valuable country (Bastin 1991a). Spelling alone will not achieve improvement in an economically viable timeframe (if at all) due to the significant hydrological change that has occurred (Friedel et al.1990).

The most common and successful technique for restoring landscapes in Central Australia is through the use of ponding banks. About 4000 hectares of country in Central Australia have ponding banks and around 25% of Central Australian pastoral properties have used ponding banks with various degrees of success (Chilcott et al. 2005). Ponding banks work by slowing the flow of water, halting erosion and recreating the fertile run-on patches that make arid zone landscapes productive. Primarily, a ponding bank works because it captures and holds water flow and allows it to infiltrate into the soil. Initially, the soil physical properties begin to improve and cracks form as clays swell and shrink. Subsequent wetting then occurs more rapidly and the swell-shrink cycle continues. Plant growth and decay can also help this process. The second stage of rehabilitation sees an improvement in soil chemical properties as coloniser plants become established. These plants bring nitrogen and phosphorus to the surface and accumulate carbon through photosynthesis. When these plants die, they contribute to nutrients near the soil surface and 'feed' the soil microbes, which help decompose litter. The third stage sees the establishment of desirable native perennial grasses from nearby seed sources (if present) or via seeding during the rehabilitation program (Bastin et al. 2001).

Alternative techniques, such as pitting and opposed-disc ploughing, also work on the same principle as ponding banks (i.e. slowing and holding water); however, they are relatively impermanent and therefore not as economically effective in the long-term in Central Australia (Friedel et al. 1996).

Sometimes landscape restoration involves diversion of water away from unstable areas into suitable drainage areas. This can be achieved using earthen banks and whoa boys. It can also be appropriate to use diversion banks to restore drainage onto areas that have become artificially droughted.

Other restoration techniques include gully stabilisation structures, which can be expensive to construct but can safely move concentrated water through a degraded landscape so that it causes no further damage.

5.4.4.1 Evidence supporting this management action

For arid landscapes to be productive, resources such as nutrients and water must be kept in close proximity to each other (Stafford Smith and Morton 1990). When these resources are decoupled, landscape processes break down and land condition declines. Landscape function analysis describes resource movement and retention within a landscape and can be used as an indicator of 'health' or condition (Ludwig et al. 2007). Source areas for nutrients and water are run-off areas. Sinks, or run-on areas are where these resources are deposited together forming fertile patches. An example of run-on/run-off patches can be seen in mulga woodlands. In these environments, dead mulga trees often fall across the slope and accumulate sediment, nutrients and water. These 'obstructions' in the landscape help retain resources in local areas as evidenced by significantly higher water infiltration rates at mulga log mounds compared with areas just a few metres up-slope. They also support greater biomass and a greater variety of plant species (Ludwig et al. 2007). Banded mulga, common on landscapes north of Alice Springs (Figure 12), is a good example of run-on and run-off processes operating at a larger scale. Run-off from the inter-grove areas is captured in the mulga groves where nutrients and water can accumulate to support abundant vegetation growth.

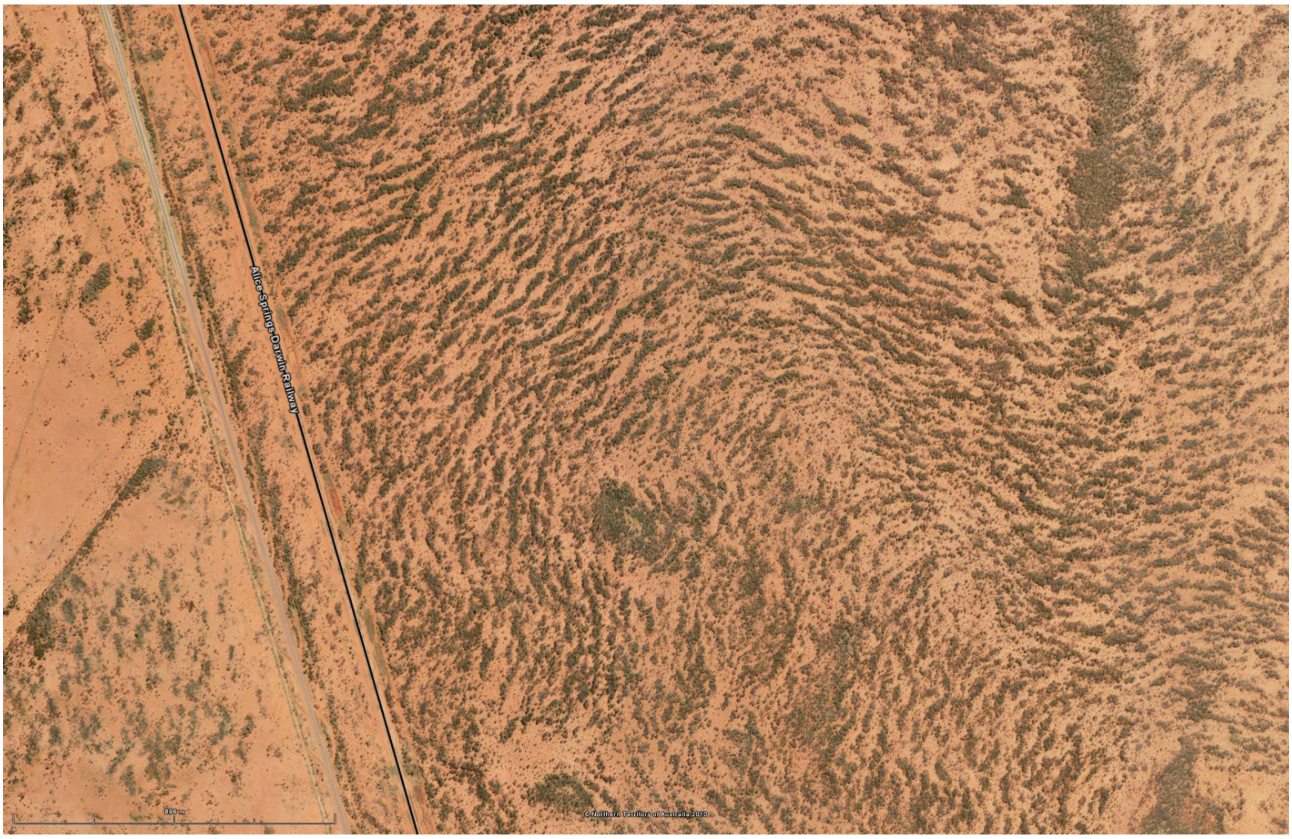


Figure 12. Google Earth image centred on S23°29'16", E133°51'34" about 25 km north of Alice Springs showing the pattern of banded mulga

Apart from capturing nutrients and water, it is important that these fertile patches have 'safe sites' for seeds to be trapped and stored. 'Safe sites' are described as having perennial vegetation, soil surface depressions or surfaces covered with litter and are important because they help to trap seeds and other resources until seasonal conditions are appropriate for germination. Kinloch and Friedel (2005b) found that as grazing intensity increased, soil loss increased, the soil surface became unstable and 'safe sites' for seeds were lost. As vegetation response becomes restricted through a lack of viable seed stores and soil erosion continues, the landscape processes break down and land condition declines.

Some of the most successful examples of land restoration in Central Australia have occurred on Woodgreen Station. Long-term overgrazing until the 1960s had resulted in bare landscapes and significantly increased run-off (Purvis 1988). In 1960, the owner began restoration with three things in mind: firstly, destocking alone was insufficient for recovery, secondly there was a need to retain water on the productive country and thirdly it was essential to have palatable perennial grasses (Purvis 1986). With these in mind, the first ponding banks were constructed and within three years, fat cattle were produced from the reclaimed area. The value of the ponding banks is demonstrated by the rehabilitation of an area known as Aldardrama Plain on Woodgreen. Prior to rehabilitation, the area was perpetually bare and erosion gullies were progressing up-slope. The plain was fenced into a 33-km^2 paddock in 1968 and from 1970 was stocked with 150 weaners for six months each year. By 1991, more banks had been constructed and stock grazed almost exclusively on the restored area resulting in an actual stocking rate of 9.1 AE/km^2 (Bastin 1991a). Given that this paddock was spelled for six months of every year, the effective annual stocking rate was 4.6 AE/km^2 reflecting the high productivity of the restored landscape. Land reclamation (predominantly ponding banks and fire) in conjunction with sustainable stocking rates and spelling have resulted in good land condition at Woodgreen. Good land condition is recognised as being more stable in terms of productivity (Friedel 1997; Chilcott et al. 2005). At Woodgreen, more stable land condition, improved herd quality and the ability to turn off finished cattle every year regardless of seasonal condition are key indicators of success (Walsh 2009e). Higher quality animals have given the owners of Woodgreen “much greater control over returns from markets”. This is an important achievement because price from market is typically regarded as a factor over which producers have little control (Bastin 1991a). A review of land reclamation techniques in Central Australia also identified the need to turn-off high quality cattle to achieve good economic value from reclamation work (Friedel et al. 1996).

There are some published analyses of the cost-to-benefit ratio of constructing ponding banks. Bastin (1991b) found that cost recovery could be achieved in five years. His assumptions included costs of approximately $236 (using contractors) for surveying, construction and seeding of each bank, the ability for the restored area to grow abundant feed, a steady increase in grazing capacity each year, an increase in live-weight gain per head and per hectare, and that capital was available for reclamation work rather than having to borrow funds. Many producers would actually undertake the construction work themselves and may therefore lower the cost of construction.

Cann (1994) found that ponding banks could be “one of the most profitable options for station development” although it is often difficult to assess the true economics. He observed that “if reclamation is undertaken on a significant area of the property, then it has the ability to reduce variation in feed supply.” Reducing variability in feed supply in a region that has high rainfall unpredictability is widely considered to be one of the most important factors to positively influence long-term sustainability (Bastin 1991a; Foran and Stafford Smith 1991; Bastin et al. 2001). Most of the research indicates that it is possible to achieve a benefit from ponding; however, accurate records need to be kept so that the analysis can be done for each situation. Machinery costs are perhaps the greatest variable, with costs dependent on ownership, maintenance requirements, fuel and labour to name a few. When considering a proposed reclamation, it is important to understand what costs are applicable to a given situation.

The use of ponding banks is also sometimes promoted as a way of producing pasture where normally there would be none. Cann (1994) noted that ponding banks can provide feed when the rest of the property is dry and therefore give an economic advantage by keeping cattle in better condition. Ponding banks can also be beneficial during below-average rainfall years (100 to 150 mm) and at the beginning of the summer rainfall season when small, isolated storms are common (Bastin 1991a). However, Sugars and Dance (2003) reported that constructing ponding banks for the primary purpose of increasing pasture growth is rarely cost-effective in a free-range grazing enterprise although it is likely to provide an economic substitute to purchasing hay when used in holding paddocks. It is important to note that Sugars and Dance (2003) did not undertake an analysis on the benefit or otherwise of using ponding banks to manage surface water flows and accelerated erosion, which is the primary application discussed in this technical guide.

Other reclamation techniques

Pitting and opposed disc ploughing are also used for reclamation. In general, they are not as successful as ponding banks because they do not tend to last for as long or provide as much useful pasture. However, after assessing 44 treated areas, the following recommendations were made as to where these techniques might be useful (Friedel et al. 1996). Primarily, they are best applied to less degraded sites where surface soils are sandy clay loam or sandier, as these allow for better water infiltration and root penetration, and where average annual rainfall exceeds 300 mm (or the site is particularly nutrient-rich or receives extra run-on). Secondary factors for enhancing success include a weak soil crust for improving infiltration success, a well-developed soil micro-topography (i.e. uneven on a scale of a few centimetres) to help trap seeds, organic material and water and a stable soil surface that does not readily collapse when wet. It is advised that these techniques be used at the beginning of summer to maximise chances of rain and that there should be no grazing until the vegetation has established (Friedel et al. 1996). Pitting and opposed discing have thus been identified as more useful for pasture improvement rather than as reclamation tools in Central Australia.

Sometimes, landscape reclamation involves other techniques to rectify drainage problems. This may include simple activities, such as installing drainage and removing windrows on graded lines to restore sheet flow across productive country. Hardened drop structures can be used to safely move water from one level to another although they are typically used in very high value areas given their expense. In some instances, particularly large erosion gullies, it may be necessary to divert water away from severely-eroded areas in order to prevent further degradation. An example of this is on Woodgreen Station where increased run-off and poorly-sited roads had created deeply incised drainage channels that left a once very productive floodplain starved of water. Allowing the pastures to regenerate on the adjacent hills slowed some run-off but the gullies were still expanding (Purvis 1988). The owner assessed the existing and former drainage patterns and successfully constructed large diversion banks to capture water from the channels and divert it back over at least part of the old floodplain. Today, the floodplain again supports a host of perennial grasses and valuable annual species.

5.4.4.2 The implementation of this practice

When faced with large areas of degraded land, it is often difficult to know where to start. The EMU process is a confidential on-property assessment of land condition issues and subsequent planning for restoration (Pringle and Tinley 2001). The EMU process has commenced on 19 Central Australian properties with support from the Centralian Land Management Association (Centralian Land Management Association 2010). The EMU process begins with a discussion of ecosystems on the property and landscape management. Pastoralists then map a variety of important features based on a land systems map, including the best and worst pastoral value country, artificial and natural waters, landscape linkages such as main drainage systems, breakaway escarpments and ridgelines and areas where many land types come together. They then map areas of severe degradation and erosion, main areas of scrub encroachment and the most fragile and sensitive landscapes. The issues are then investigated in the field with discussions on critical landscape processes and how landscapes are linked. Problem areas are assessed to determine if the cause is local or further afield. Prioritisation occurs as a result of mapping landscape features and issues and identifying where they coincide and the linkages between them. Participants plan restoration works using experts as they need them. A realistic timeframe for undertaking restoration work is identified to help achieve success on a case by case basis (Pringle and Tinley 2001).

Accurately identifying the cause of a land condition problem is vital because the cause is not always local. There are many examples of reclamation works that have been unsuccessful because they have focussed on the "symptoms" or end result of a land condition problem rather than tackling the primary cause. The mapping and property inspection process described above helps to identify the locations of these primary causes and the appropriate methods for managing them. EMU recommends starting restoration works (usually calming and spreading water flow) at the source of the problem and gradually working down-slope (Pringle and Tinley 2001). This progressive approach also allows restoration to be carried out in stages that might be more appropriate to the resources available (e.g. time, labour, finances) and it facilitates restoration within the system itself as the processes are gradually brought back into line.

It is commonly recommended that rehabilitation should begin on the more productive areas and where there is a high chance of success as these potentially offer the greatest cost-to-benefit ratio (Ludwig et al. 1990). It is also widely emphasised that high quality finished cattle that will attract high prices when sold, are essential to maximise the economic benefit from restoration work (Bastin 1991a; Friedel et al. 1996).

There is a lot of written information available regarding the design, construction and maintenance of ponding banks (e.g. Bastin 1991a; Bastin et al. 2001; NRETAS 2007a,b). There are also many producers in Central Australia with experience in using ponding banks. Ponding banks are typically constructed on gentle slopes of <2%. The ponding bank method is designed to slow water flow, hold a small proportion at a safe ponding depth and spill the excess water down-slope to the next bank or onto a stable, flat or well-vegetated area. Slowing and temporarily holding the water increases infiltration, improves soil nutrient status and provides conditions for plant establishment.

Attempts to hold all run-off from a catchment will result in bank failure. On the steeper parts of the slope, banks should be small and quite flat in shape so that they allow water to exit without causing erosion and so that the dammed water does not break through the banks. Banks can become larger down-slope once some of the run-off has been controlled by the smaller banks farther up-slope.

It is important that all ponding bank locations are surveyed to ensure that they are correctly positioned in relation to the contour. It is not possible to accurately assess slope and contour by eye, so the use of a dumpy level or laser level is essential. For maximum success, banks should be angled just off the contour so that they pond a maximum of about 10 cm of water. It should be noted, however, that some highly experienced producers have successfully used ponding depths of up to ~25 cm. Opinions on ideal ponding depth probably vary due to differences in soil type and infiltration rate. A good rule of thumb is that banks should not hold standing water for more than about 24 hours, otherwise plants can become waterlogged and die. If banks are found to pond water for too long, PVC pipes can be installed to drain them (Bastin 1991a).

Opinion varies on whether the soil for the bank should be pushed from up-slope or down-slope. Some people push from down-slope to maintain an undisturbed soil surface in the ponded area (Bob Purvis, Woodgreen Station, pers. comm.) whilst others believe that disturbance in the ponded area benefits water infiltration. Regardless of approach, vegetation succession and establishment improves over time, starting with coloniser species and gradually moves towards palatable, perennial species (Bastin 1991a).

It is important that producers recognise there may be a need for ongoing maintenance (stock pad breach) and/or replication (Ludwig et al. 1990). It is recommended that cattle are kept off new banks until they have settled properly. Fresh earthworks may be susceptible to damage if the first storm they receive is extraordinarily intense. It is important to accurately identify the cause of breaches. If the run-off is excessive in either volume or velocity, then more banks are required up-slope. Construction techniques may also be at fault if the bank was not big enough or was not aligned correctly. Given the lack of hydrological information for much of the rangelands, it is wise to be cautious and construct numerous smaller banks with a flatter or downturned shape so that only small volumes of water are ponded. Most operators find that as they gain confidence and experience they become more proficient in their technique and can successfully build larger banks in appropriate areas (Bastin 1991a).

Diversion banks should be constructed with very gentle falls (<0.2%). For all types of banks, care should be taken to spill water onto a safe location or erosion will occur. Safe locations include areas of stable soils, good pasture cover and gravelly or stony areas. It is important that the spill locations are broad almost flat areas that can gently spread concentrated water across a large area.

When seeding is undertaken in Central Australia, it is usually one of the varieties of buffel grass that is used. A project exploring the use of Central Australian native grasses found that many species have great potential for rehabilitation when applied in the right environments (Reu 1996). Native grasses, such as barley Mitchell grass (*Astrebla pectinata*), desert bluegrass (*Bothriochloa ewartiana*), Qld bluegrass (*Dichanthium sericeum*) and native millet (*Panicum decompositum*) establish readily and can outperform buffel grass on heavy soils (Reu 1995). Other native grasses, such as brown beetle grass (*Leptochloa fusca*) can establish readily on very poor soils, providing useful early succession plant establishment that helps improve nutrient cycles and soil properties for preferred perennial species. The benefits of using native grasses include the ability to grow on a range of soil types, strong drought tolerance and good palatability (Reu 1995). Using native seed will typically involve harvesting and storing local seed as it is mostly not commercially available. Recommendations are that seed should be stored for one or two years prior to use to overcome most dormancy; sowing depth should be between 5 to 10 mm at a rate of 150 to 200 viable seeds/m^2 (Reu 1996). Sowing should occur in November as the chance of receiving carry-over rainfall is higher in December, January and February. Seed can be sown mechanically, using a pitter or opposed disc plough (with some modification), or by hand. It is recommended that seed is buried during sowing to reduce theft by harvester ants (Reu 1996).

There are techniques and skills that need to be learnt in order to construct successful land restoration works and this information is available locally from the NT Department of Land Resource Management and the Centralian Land Management Association. More importantly, producers that observe, analyse and understand the hydrological processes at work on their properties gain a level of knowledge that makes it possible to design appropriate techniques for restoring landscapes.

5.4.4.3 Considerations/caveats

Restoration of a landscape occurs in stages (i.e. soil physical properties improve, followed by early succession plant species, better nutrient cycling and eventually perennial plant establishment). It is important to recognise that these processes take time, even when rainfall conditions are favourable. Producers should not be disheartened if early results are not as good as they had anticipated.

Eventually, with appropriate stocking rates and spelling, the land adjacent to ponded areas should also begin to show land condition improvement (Purvis 1986; Bastin 1991a). In some instances, very wet years might be necessary to trigger large-scale recovery of land condition.

The green feed associated with successful reclamation work has the potential to attract significant numbers of feral animals and kangaroos. Kangaroos had to be controlled on some of the first ponding banks constructed at Woodgreen Station. However, over time, the significant increase in land condition and forage availability means that although kangaroos may increase in favourable seasons, they have minimal impact on the amount of fodder (Bastin 1991a). Prior to large scale restoration of limestone country on Mt Riddock Station north-east of Alice Springs, the owners undertook an intensive program of rabbit control so that subsequent increases in pasture availability were not lost to feral animals (Bastin 1991b). Another management option that has been used to maximise the success of reclamation works has been to leave dingo populations intact so that they can control rabbit numbers (Purvis 1986).

Sometimes woody species will become thick in ponded areas and fire may be necessary to reduce their density. Thickening may occur because of insufficient ponding, as demonstrated by the following example from south-west Qld. Where banks were only ponding 75 mm of water, producers were required to slash juvenile woody shrubs in the run-on areas of the banks to help encourage grass growth before a sufficient fuel load developed to carry a fire (Bull 2003). If it is a relatively small area, chemical or mechanical control may be suitable. Control will be most successful if undertaken when the woody plants are young and relatively small. Conversely, ponding banks can be used to accumulate fuel loads adjacent to areas of woody thickening.

5.4.5 Essential management action 2: use pasture spelling to allow pastures to regenerate

Minimal gains will be made with restoration efforts if pastures are not spelled until they are well established. This is because grasses need to grow new leaves before they can direct energy into root development. A deep reaching, robust root system helps ensure that perennial grasses will survive dry periods and respond quickly to subsequent rain. If new leaf growth is consistently grazed then it is not possible for the root system to become well established. Spelling until the first seed set has occurred and occasional spelling thereafter will promote root development (Chilcott et al. 2005). Similarly, spelling will be required to maximise productivity once landscapes are fully restored. Section 5.2 describes the principles and options for implementing spelling.

5.4.5.1 Evidence supporting this management action

Rehabilitation of landscapes occurs in stages. The amount and rate of nutrient cycling will lag behind improving soil infiltration and vegetation establishment because a full range of flora and fauna activity is required to maximise nutrient cycling. This is important for a number of reasons. Restoration projects that aim to meet conditions favourable for several factors can facilitate more efficient rehabilitation. It also highlights the importance of allowing for full restoration before grazing resumes (Tongway 1990). Cann (1994) highlighted the need for the reclamation work to be destocked until the pastures have had time to become established in order to maximise the economic benefits.

A pasture reseeding demonstration at Alcoota Station north-east of Alice Springs showed the importance of spelling restoration works. The trial showed a significant increase in buffel grass frequency and yield in a grazing exclosure compared with a grazed site. The exclosure allowed 140% more buffel seedlings to become established on the tine pitted areas and 32% more seedling establishment on the opposed disc ploughed areas (Campbell 1992). Seeding trials in Central Australia also found that the second growing season plays an important role in determining longevity of plants and conservative grazing is recommended for this period (Reu 1996).

Rehabilitating large landscapes will usually require staged construction over a number of years due to available funds and time. Older banks can provide a good source of seed for newly-constructed banks (Bastin 1991a) provided they are also occasionally spelled to allow abundant seed to develop.

In summary, the long-term success of restoration works relies almost entirely on appropriate stocking rates and grazing strategies that provide spelling (Purvis 1986; Green 1989; Bastin 1991a; Friedel et al. 1996).

5.4.5.2 The implementation of this practice

Section 5.2 describes the principles and options for implementing spelling.

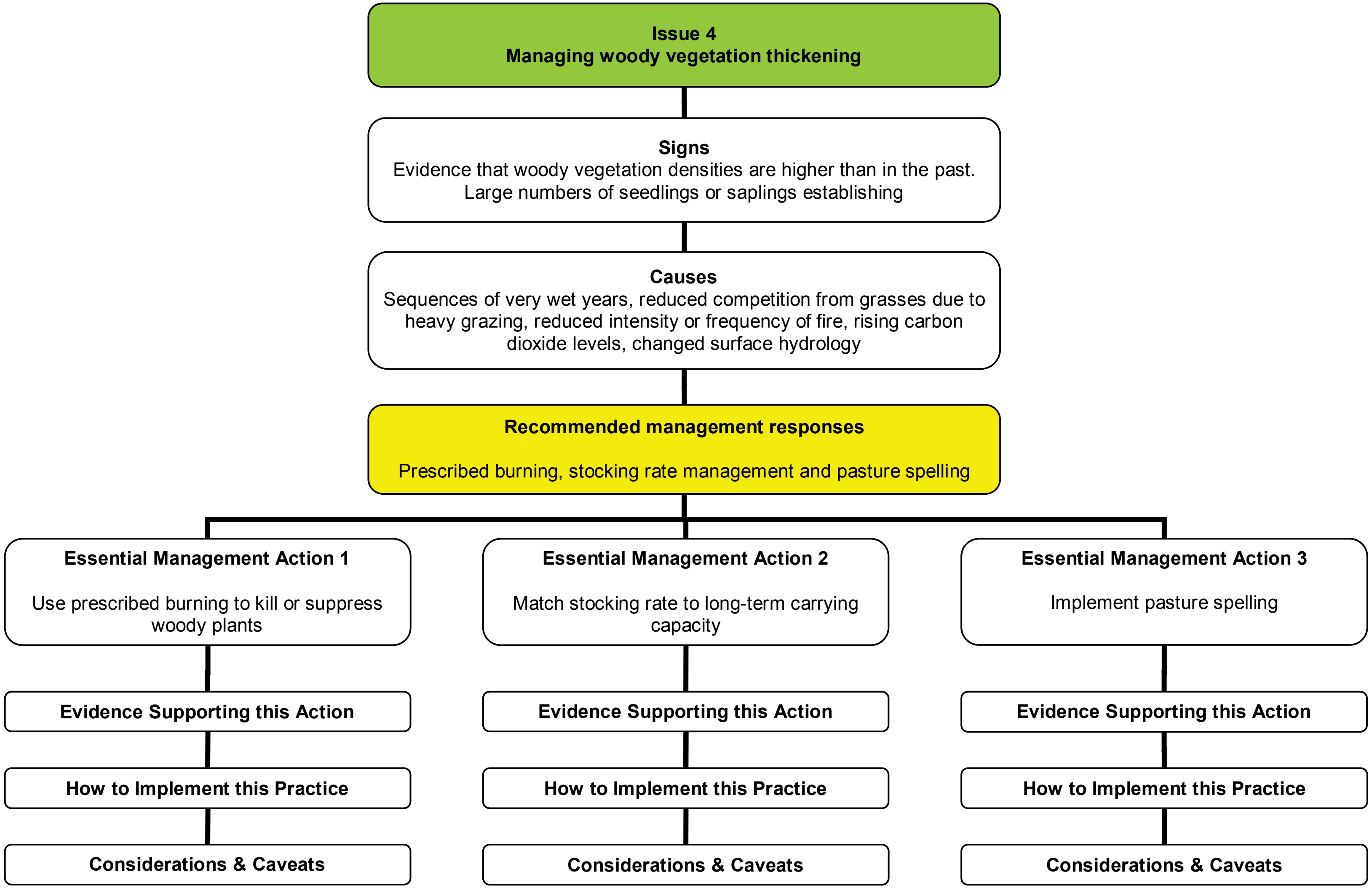
5.4.6 Essential management action 3: use forage budgeting to adjust stocking rate to seasonal conditions

Section 5.2 describes how to match animal demand and pasture supply using forage budgeting.

5.4.7 Complementary management action 1: use prescribed burning to reduce woody species density

Sometimes woody shrubs can form dense thickets as a result of either too much water or erosion-accelerated ‘droughting’. In other instances, woody thickening may have occurred through some other process and is subsequently outcompeting pasture growth leading to bare ground and an increased erosion hazard. The first step is to assess natural drainage patterns and restore appropriate hydrology if necessary.

Techniques for this are described previously in this section. Fire may be a useful tool to reduce the density of woody vegetation and this is discussed in detail in the following section.


Issue 4
Managing woody vegetation thickening
Signs
Evidence that woody vegetation densities are higher than in the past. Large numbers of seedlings or saplings establishing
Causes
Sequences of very wet years, reduced competition from grasses due to heavy grazing, reduced intensity or frequency of fire, rising carbon dioxide levels, changed surface hydrology
Recommended management responses
Prescribed burning, stocking rate management and pasture spelling
Essential Management Action 1
Use prescribed burning to kill or suppress woody plants
Essential Management Action 2
Match stocking rate to long-term carrying capacity
Essential Management Action 3
Implement pasture spelling
Evidence Supporting this Action
How to Implement this Practice
Considerations & Caveats
Evidence Supporting this Action
How to Implement this Practice
Considerations & Caveats
Evidence Supporting this Action
How to Implement this Practice
Considerations & Caveats

5.5 Issue 4: Managing woody vegetation thickening

In Central Australia, pastoral enterprises are underpinned by native vegetation that almost always includes a tree and shrub component. This woody vegetation varies greatly both within and between vegetation types, in terms of the density and biomass of woody plants, the structure of the woody strata and the species composition.

Woody species vary in their growth form, mode of reproduction and reproductive output, mode of seed 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 and temporal variation in the woody component of Central Australian vegetation.

Although the woody component of Central Australian pastoral lands is naturally dynamic, in many areas there is concern that since pastoral settlement, there has been a trend of increasing density. This increase comes from three sources: (i) thickening of native understorey (shrub) species; (ii) increased density of native overstorey (tree) species; and (iii) invasion by exotic trees and shrubs. Different species are involved in different locations but often multiple species are involved.

Woody plants can be problematic for pastoral production reliant on 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 livestock carrying capacity.
- Some woody plants are toxic to livestock.
- Dense stands of woody plants can inhibit livestock access to water.
- Dense woody vegetation can interfere with efficient animal husbandry (e.g. mustering).
- Thickets of woody vegetation and/or the often bare surface soil can significantly alter natural drainage patterns resulting in 'droughting' and accelerated erosion.

It is also true that some species of woody plants, both native and exotic can provide shade and useful browse (which may contribute significantly to livestock diets in some land types and climatic conditions), as well as provide important habitat, contributing to biodiversity values, nutrient cycling and (for some species) nitrogen fixation.

The most common native woody species that tend to increase in Central Australia include mulga (*Acacia aneura*), witchetty bush (*Acacia kempeana*), needlebush (*Acacia tetragonophylla*), ironwood (*Acacia estrophiolata*) and broombush (*Senna artemisioides*) (Friedel 1985).

5.5.1 Signs

As described in the previous chapter, moisture and nutrients tend to accumulate in specific parts of the landscape and this determines where vegetation grows. However, the biomasses of woody and herbaceous components of the vegetation are usually 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 pasture 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.

Historical recollections 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, aerial photographs and satellite imagery often provide useful and reliable evidence. 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 because other causes (such as frequent fire) can produce similar results. The presence of such species as rubber bush (*Calotropis procera*) and parkinsonia (*Parkinsonia aculeata*), which are known invasive species, indicates a threat of increasing non-native woody species.

5.5.2 Causes

Many factors drive tree and shrub populations. Some of the important ones are indicated in Figure 13, which portrays the dynamic balance between woody and herbaceous (mainly grass) components of the vegetation. The main drivers of the dynamic are effective rainfall as a promoter of germination and growth, and drought or low rainfall as a cause of mortality. Competition between grasses and woody species (for water, nutrients and/or light) has a negative impact on grasses, while grazing and fire remove herbaceous biomass. Fire also causes top-kill and mortality of woody species, as does browsing by some animals (e.g. rabbits). Some of these factors can be managed and some cannot. The factors that drive increases in woody plants include sequences of very wet years, reduced competition from grasses due to heavy grazing, reduced frequency and/or intensity of fire or, as suggested in some literature, rising carbon dioxide levels. The significance of these factors is likely to vary from place to place.

One important relationship is plant size versus susceptibility to fire. For many species, small plants are more susceptible to fire than large plants. The longer an area goes unburned, the more resistant to fire it can become because increasing woodiness reduces pasture growth and the incidence of fire due to low fuel loads. For some land types this creates woody ‘deserts’ that become self-sustaining due to the very low fuel available for fires.

There is also an important link between natural drainage patterns and woody species. Soil moisture levels (quantity and longevity) decline as run-off increases making it more difficult for grasses to thrive and therefore favouring the establishment of deeper-rooted plants like shrubs and trees. Diversion of natural run-off through incisions and barriers such as erosion gullies, stock pads and infrastructure will also adversely affect soil moisture levels (see Section 5.4). This type of shrub encroachment may be more difficult to detect as it tends to happen gradually compared with a cohort of individuals arising from a particular event, such as exceptional rainfall (Pringle and Tinley 2003).

The management questions that arise for managing woody vegetation thickening are:

a. What combination of prescribed burning and grazing management will minimise woody vegetation thickening?

b. What are the best prescribed burning regimes to manage woody vegetation?

c. How can I restore natural drainage patterns to support competitive ground cover?

5.5.3 Management responses: prescribed burning, grazing management and maintaining natural drainage patterns

Fire, grazing, browsing and maintaining natural drainage patterns are the key manageable factors that influence the woody components of Central Australian vegetation. Critically, two of these factors interact with one another because herbivores and fire compete for grass (Figure 13). Prescribed burning is likely to be an appropriate management response for controlling woody vegetation thickening in Central Australia. Given that the amount of cover provided by the herbaceous material can directly affect run-off, grazing management also has a role to play in maintaining hydrological processes. Management also needs to ensure that natural drainage patterns are maintained in the broader landscape with relation to the construction and maintenance of infrastructure (see Section 5.4).

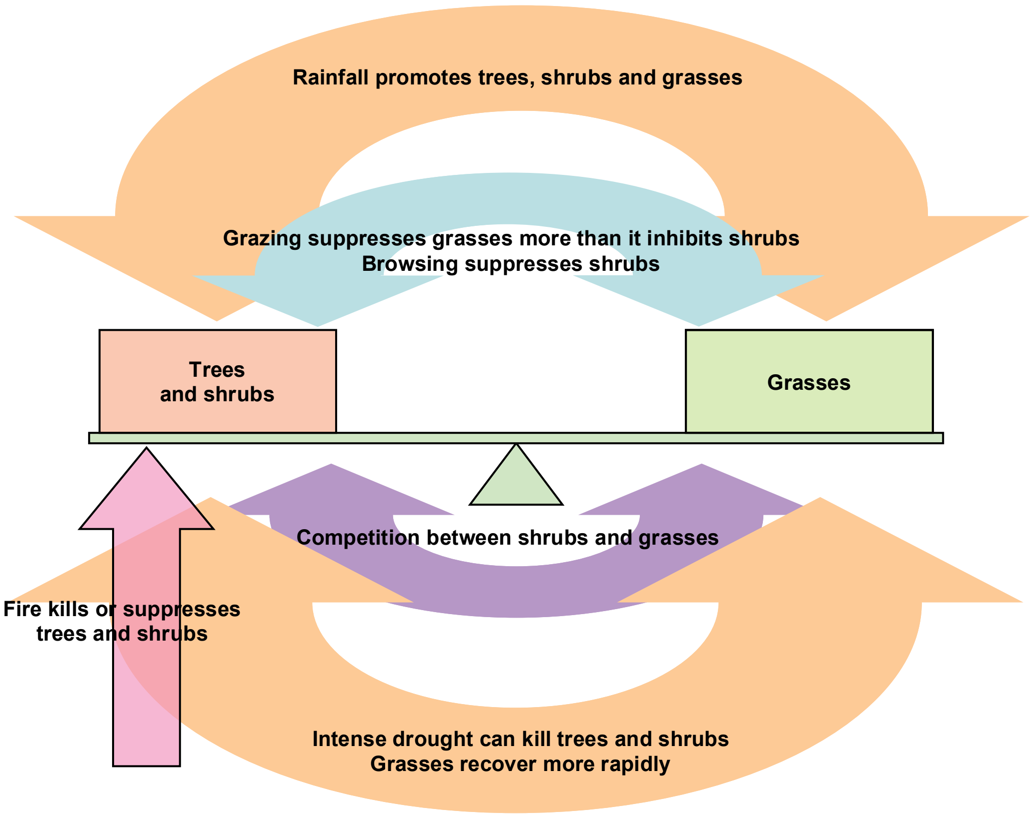


Figure 13. Factors that affect tree and shrub populations (McIvor et al. 2010)

5.5.4 Essential management action 1: use prescribed burning to kill or suppress woody plants

If woody plants are reaching densities or a biomass that is deleterious, prescribed burning is one of the options available to land managers. The most useful burning regime will depend 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 (small) shrubs.

5.5.4.1 Evidence supporting this management action

Much of the fire research that has been conducted in Central Australia has focused on the ecology and management of spinifex country. This reflects the common scenario in Central Australia that most opportunities for fire are restricted to spinifex country where highly flammable, large and continuous fuel loads can occur. The exception to this is following high rainfall years where fuel loads and continuity increase across the whole landscape and very large wildfires can occur (Greenville et al. 2009).

In the early 1970s, Central Australia experienced some of the wettest seasons on record, resulting in a mass germination of mulga seedlings. Normal pastoral management practice is to suppress fire because it destroys cattle feed. Unfortunately, this suppression favours the establishment of woody seedlings and woody thickening is the result. In the late 1970s, CSIRO conducted experiments using fire to reduce shrub density. The results showed that cool, winter burns in mulga woodland were as effective as summer burns in reducing the density of mulga plants. Winter fires are less intense than summer fires and are less likely to initiate mass germination of mulga seedlings and are therefore recommended for controlling young invasions (Griffin and Friedel 1984a).

A study by MacLeod and Johnston (1990) showed that prescribed burning was the only economically effective treatment for controlling woody species in western NSW. They estimated that fire would cost approximately \$50/km^2 to implement. Cann (1991) also completed an economic analysis of using fire to control woody species in Central Australia and found it to be in the order of hundreds of dollars per square kilometre to implement. This compared with other techniques, such as chaining (\$800 to \$2000/km^2), blade ploughing (\$8300 to \$10 000/km^2) and chemical treatment (\$7500 to \$22 000/km^2). Blade ploughing and chaining were also found to be the least economically effective in the study by MacLeod and Johnston (1990). It is not uncommon for mechanical disturbance to encourage germination (perhaps as a result of better water infiltration and seed/soil contact) (Bull 2003) and a follow-up burn should be planned to enhance the benefit gained if mechanical techniques are used.

When the costs and benefits of various burning regimes were compared using modelling, the results confirmed that burns are usually only possible in grazed areas of Central Australia after very high rainfall years. A model simulation was conducted for an open woodland land type between 1981 and 2010. Land condition was set to B at the start of the simulation and burns were allowed to occur whenever total standing dry matter reached ≥800 kg/ha. The results showed that this target was only achieved four times during the simulation (in 1982, 1983, 2000 and 2001). When the same simulation was run starting in C land condition, it was only possible to achieve a burn in 2001. This is because the poorer land condition meant lower vegetation growth and fuel loads only exceeded 800 kg/ha after this very wet period. Three scenarios are shown in the results below: never burn, burn when the threshold is reached (under continuous grazing) and burn when the threshold is reached (using spelling to increase fuel loads). In the spelling simulation, spelling was initiated when it was known that rainfall would be adequate to stimulate grass growth. In reality, weather forecasting tools are not yet reliable enough to accurately predict rainfall; however, if spelling is already a part of a grazing strategy, it offers the potential to increase fuel loads in average to high rainfall years. In the spelling scenario, spelling was implemented in the model from 1 May 1981 to 1 May 1982 and from 1 May 2000 to 1 May 2001 in order to enhance the pasture growth for fires in 1982 and 2000, respectively. Because spelling lasted 12 months, it also provided spelling after the 1982 burn and before the 1983 burn so a second spelling period was not required. Similar benefits also resulted in the spelling period of 2000-01.

Figure 14 shows that stocking rate did not vary much between treatments until the mid-2000s when the additional pasture growth in the two burn scenarios allowed stocking rates to increase compared with the unburnt treatment.

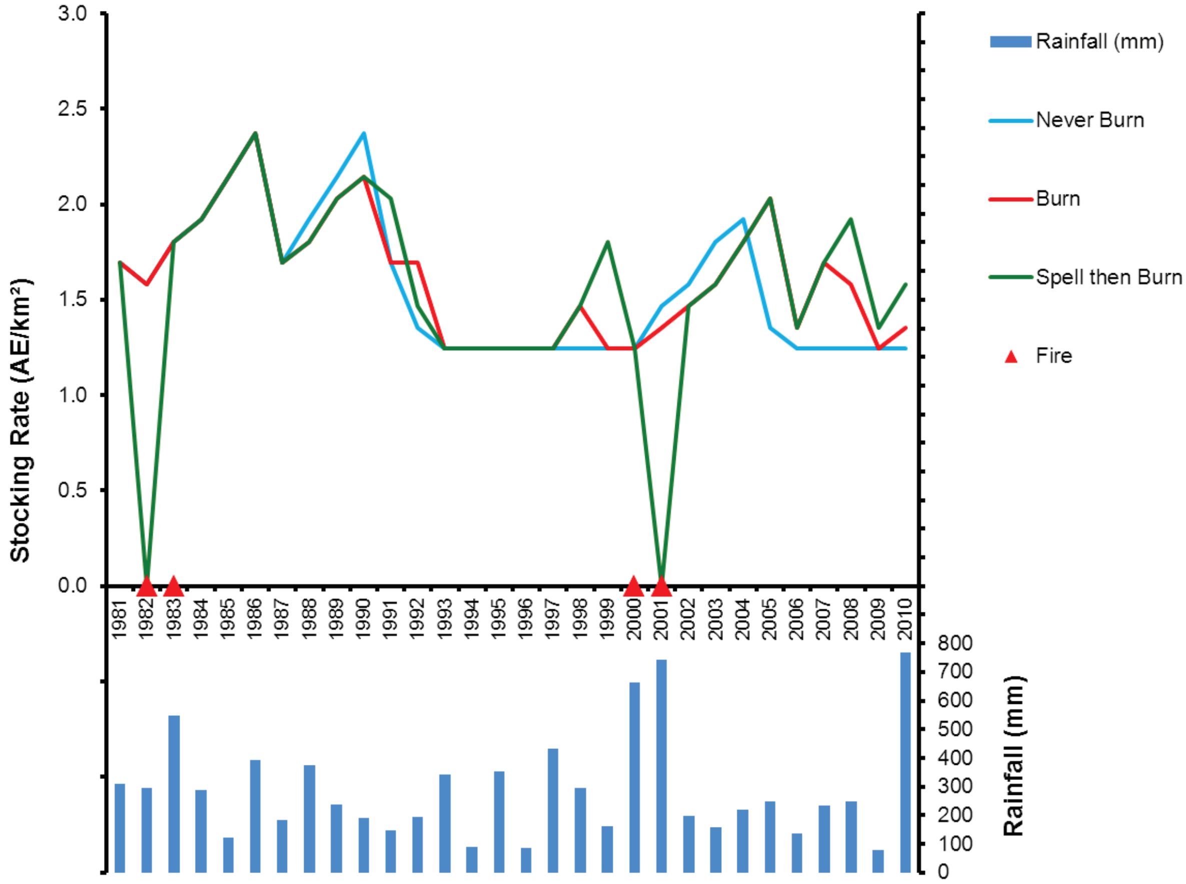


Figure 14. GRASP simulation showing the interaction between burning scenarios and stocking rate for open woodland starting in B land condition in the Alice Springs region (1981-2010). Burns (indicated by red arrows) were implemented as cool fires on 30 June whenever total standing dry matter exceeded 800 kg/ha. Spelling was implemented when it was known that good rainfall would be received in order to further enhance fuel loads and ran from 1 May for 12 months. Figure 14 indicates the fluctuations in stocking rate in response to available dry matter and the destocking required to achieve a spell. Stocking rates were similar between the burning and never burn scenarios until about 2004 when pasture growth in the two burning scenarios was higher than in the never burn scenario. This is attributed to an increase in pasture growth due to a reduction in competition from trees and shrubs. Note that the rainfall shown is from 1 January to 31 December each year, whereas the model output year is 1 May to 30 April.

Figure 15 shows the change in tree basal area (the cover of tree stems (m^2/ha) in a given area), which is an indication of woody vegetation density. While bigger reductions were made after the very wet years of 2000-01, the reduction in tree basal area from the fires in 1982 and 1983 also provided benefits. In the never burn treatment, the tree basal area increased to high levels during the course of the simulation, leading to suppressed pasture growth and a reduction in land condition and carrying capacity.

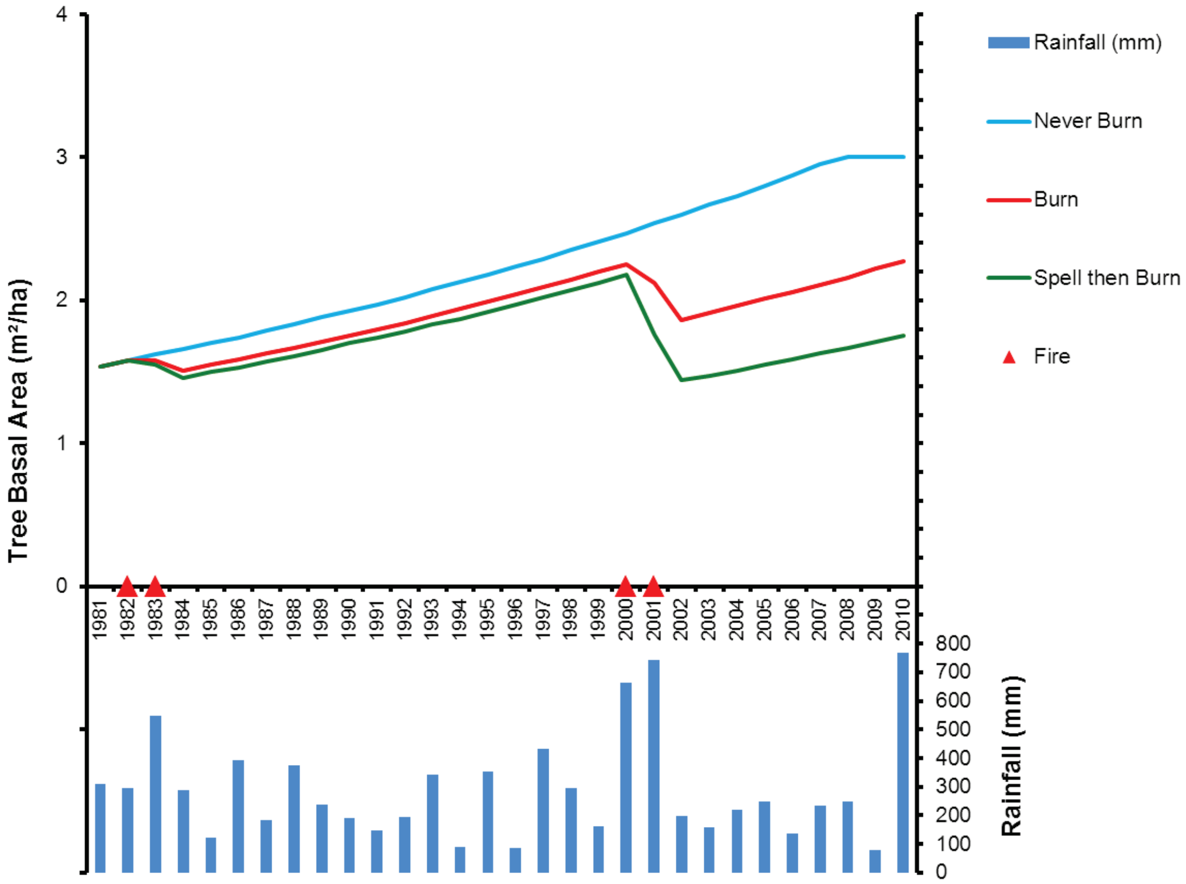


Figure 15. GRASP simulation showing the effect of fire on tree basal area for open woodland starting in B land condition in the Alice Springs region (1981-2010). Burns (indicated by red arrows) were implemented as cool fires on 30 June when total standing dry matter exceeded 800 kg/ha. Both burn scenarios resulted in a reduction in tree basal area compared with the never burn scenario. Spelling followed by burning had a greater reduction in tree basal area because the extra accumulation of fuel resulted in a hotter fire. Note that spelling was implemented when it was known that good rainfall would be received in order to further enhance fuel loads and ran from 1 May for 12 months. The rainfall shown is from 1 January to 31 December each year whereas the model output year is 1 May to 30 April.

In the simulation, the benefits of the 1982 and 1983 fires for land condition and carrying capacity started to become apparent from 1993 onwards, with an increase in pasture growth in the burnt areas compared with the never burnt area (Figure 16). This extra pasture growth meant that pasture utilisation rates effectively declined in the burnt areas, resulting in improvements in land condition.

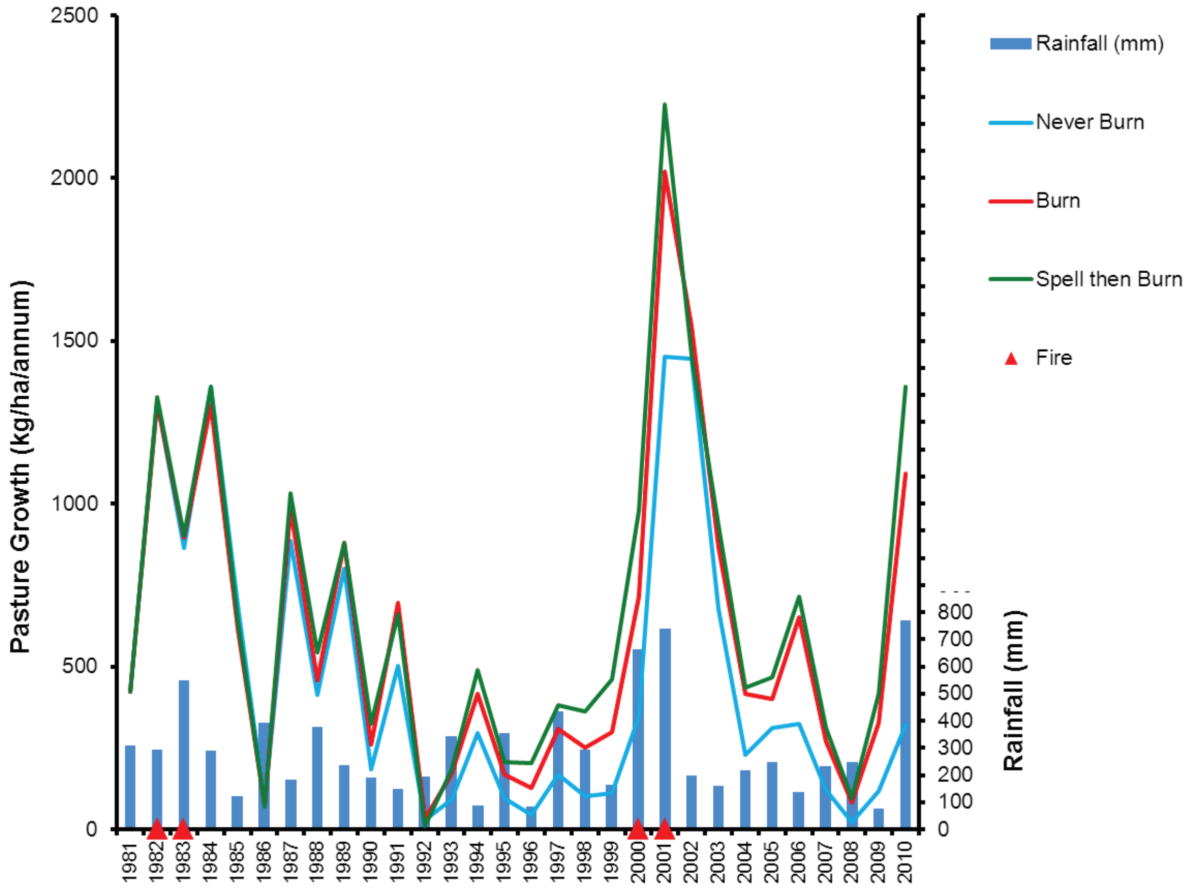


Figure 16. GRASP simulation showing the effect of fire on pasture growth for open woodland starting in B land condition in the Alice Springs region (1981-2010). Burns (indicated by red arrows) were implemented as cool fires on 30 June when total standing dry matter exceeded 800 kg/ha. Both burn scenarios resulted in an increase in pasture growth compared with the unburnt treatment from 1993 onwards as a result of the decreased competition from trees and shrubs. Figure 16 highlights the difficulty of achieving sufficient growth to successfully carry a fire except for the very wet periods. Note that spelling was implemented when it was known that good rainfall would be received in order to further enhance fuel loads and ran from 1 May for 12 months. The rainfall shown is from 1 January to 31 December each year, whereas the model output year is 1 May to 30 April.

Although the stocking rate was flexible, it was not reduced to match the declining pasture growth in the never burn scenario and therefore the pasture utilisation rate increased as the land condition declined. This resulted in a decline in land condition (Figure 17). In the burnt scenarios, the increased pasture growth meant that the pasture utilisation rate declined and land condition subsequently improved. The scenario incorporating spelling and burning further improved land condition as the tree basal area was lower as a result of the more intense fire achieved through higher fuel loads.

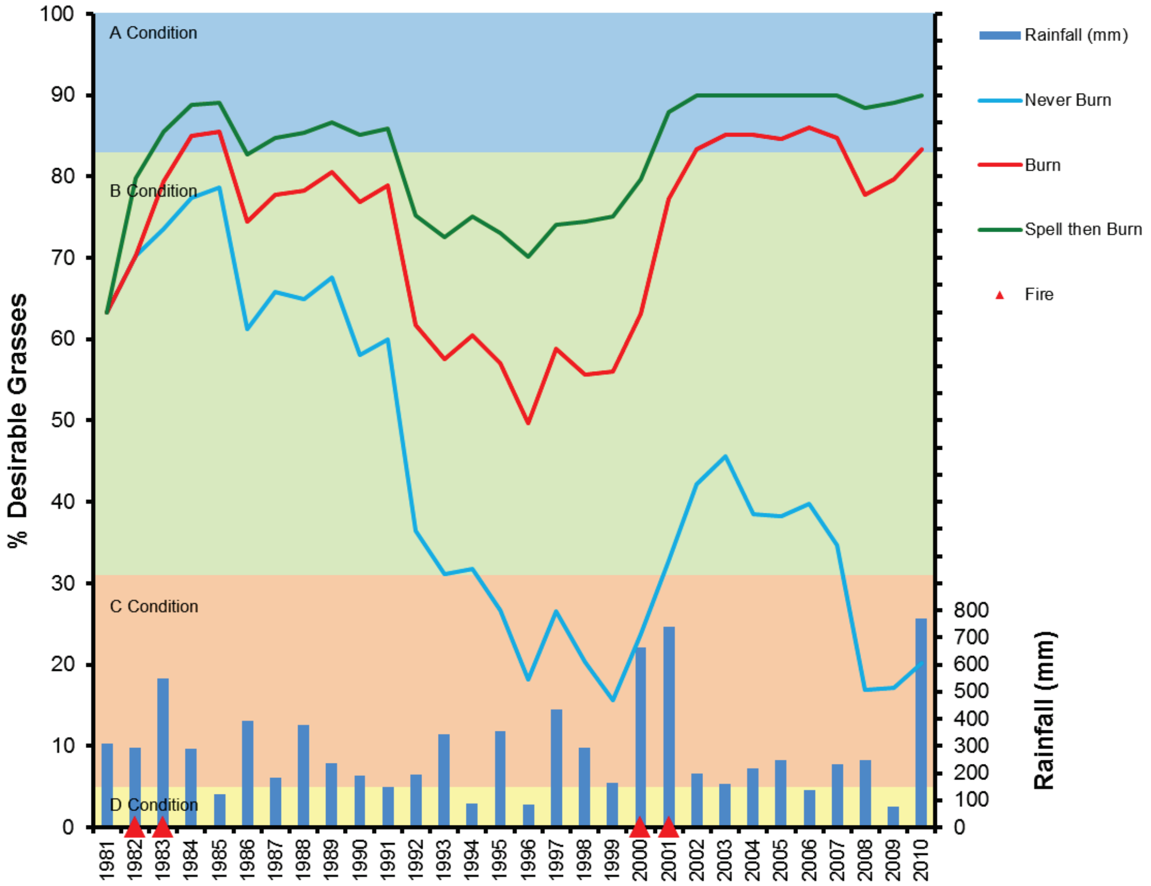


Figure 17. GRASP simulation showing the effect of fire on land condition for open woodland starting in B land condition in the Alice Springs region (1981-2010). Burns (indicated by red arrows) were implemented as cool fires on 30 June when total standing dry matter exceeded 800 kg/ha. Both burn scenarios resulted in an improvement in land condition while the never burn scenario declined in land condition as the competition from trees continued to increase. Percentages of desirable grasses in the pasture are used as a proxy for land condition. Spelling was implemented when it was known that good rainfall would be received in order to further enhance fuel loads. Spelling ran from 1 May for 12 months. The rainfall shown is from 1 January to 31 December each year, whereas the model output year is 1 May to 30 April.

Many producers want to know the costs and benefits of conducting burns. O'Reilly (2001a) reported that benefits often take the form of preventing a loss of income rather than actually making more money. This is well illustrated in Figure 18 as LWG/ha declined below the starting point in the never burnt scenario, whereas the burnt scenarios retained their initial LWG/ha. As trees became thicker in the never burnt scenario, pasture growth and land condition declined. If stocking rates are not reduced to account for the declining pasture growth, utilisation rates increase causing further negative impact on land condition. This creates a perpetual cycle of declining land condition and pasture growth, further diminishes the opportunities for fire and ultimately leads to a decline in LWG/ha (Figure 18).

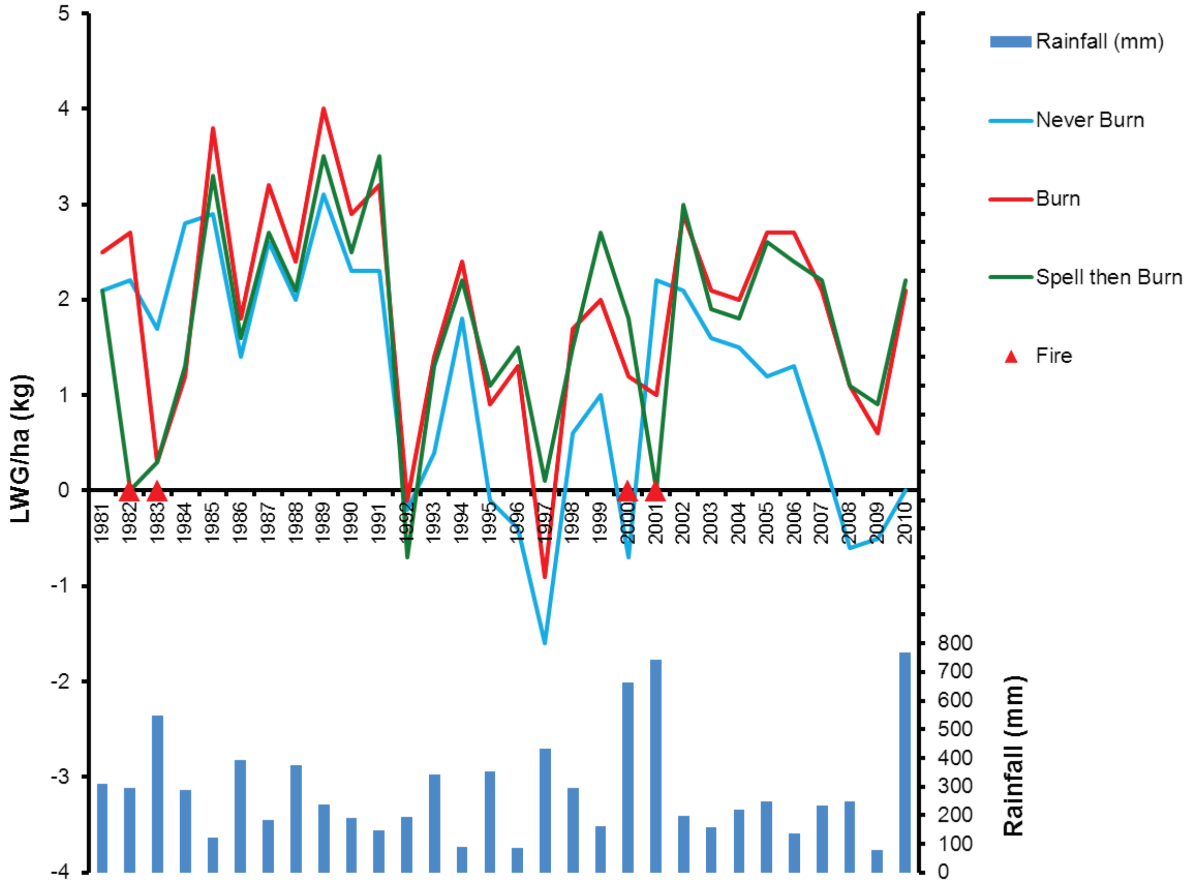


Figure 18. GRASP simulation showing the effect of fire on live-weight gain/ha for open woodland starting in B land condition in the Alice Springs region (1981-2010). Burns (indicated by red arrows) were implemented as cool fires on 30 June when total standing dry matter exceeded 800 kg/ha. Both burn scenarios achieved higher pasture growth rates and therefore better LWG/ha throughout the simulation. The unburnt area had lower LWG/ha as a result of lower pasture growth. Note that spelling was implemented when it was known that good rainfall would be received in order to further enhance fuel loads. Spelling ran from 1 May for 12 months. The rainfall shown is from 1 January to 31 December each year, whereas the model output year is 1 May to 30 April.

Modelling was also undertaken to determine the economics of incorporating pre-fire spelling into the fire strategy. When stock were moved into other paddocks on the property, the financial performance was better than if they were agisted elsewhere, but this approach sometimes caused a crash in land condition in other paddocks. When agistment was used instead, the spell plus burn scenario had similar profitability to the burn only scenario because the better land condition allowed higher stocking rates to be run and the subsequent increased production exceeded the agistment costs. The spell plus burn scenario also had the additional benefits of improved land condition and lower tree basal area (Table 10). Note that post-fire spelling was not factored into this scenario analysis. Spelling after burning may also be required to ensure enough feed is available and to promote good land condition.

Although the average economic benefits appear to be quite small in this scenario, it should be noted that they would start off quite negligible at the beginning but would increase markedly with increasing tree basal area and the subsequent declines in land condition in the never burn scenario. Projected out over the next 30 years, the economic differences would be expected to become quite considerable.

Table 10. Profit outcomes for a range of burning scenarios for an Alice Springs representative property (1981 to 2010). The analysis assumed that all pastures were in B land condition at the start of the simulation (1981). Note that when mulga and oatgrass land types were modelled starting in C condition, the poorer pasture growth meant that a fire was not possible until 2001 when fuel loads exceeded 800 kg dry matter/ha.

Profit	Never burnt	Burnt	Spell+burn (with agistment costs)	Spell+burn (no agistment costs)
Average	$223 729	$261 072	$260 406	$282 308
Minimum	-$511 158	-$551 438	-$517 983	-$517 983
Maximum	$890 915	$1 000 868	$780 343	$780 343
No. of negative years	8	5	5	3
Net present value	$4 394 060	$4 768 569	$4 541 246	$5 029 984

5.5.4.2 The implementation of this practice

After a series of high rainfall years, (i.e. at least two consecutive years of above-average rain), fuel loads can be quite high and shrub seedlings can also become prolific (Friedel 1985; Chilcott et al. 2005; Edwards et al. 2008; G. Allan pers. comm. November 2011). This is the optimum time for assessing landscapes. If shrub seedlings are dense, then a burn should be implemented. Studies conducted by Friedel (1985) on the population structure and density of Central Australian trees and shrubs used the following classifications for identifying when woody vegetation density is a problem and provides a guide for deciding when to act (Table 11).

Table 11. Guidelines for assessing actual or potential areas of problematic woody vegetation density (derived from Friedel 1985). For example, mulga seedlings are considered a problem where there are more than 800 seedlings/ha (0.10 – 0.50 m tall).

Land type	Height class (m)	Problematic density (individuals/ha)
Open woodland	0.10-0.50	>1,000
	0.51-1.00	>400
	1.01-2.00	>300
Mulga annual	0.10-0.50	>800
	2.01-4.00	>150

Continuous and abundant dry fuel is needed for a fire to carry across the landscape. To achieve a successful hazard reduction/pasture improvement burn in spinifex country, a cool season fire with fuel loads of 2000 to 3000 kg dry matter/ha is recommended (Chilcott et al. 2005). To control juvenile shrub increases, an early intervention burn is recommended and should also be undertaken in cool conditions with >1000 kg dry matter/ha of fuel. Where the woody shrubs are more mature and have suppressed understorey growth, a remedial burn will require hot and windy conditions and a fuel load >1500 kg dry matter/ha (Chilcott et al. 2005).

High intensity fires can damage vegetation, which is why they are good for controlling woody species. However, achieving a good outcome depends on the species being targeted. For example, high intensity fires kill mature broombush (*Senna* spp.), mulga (*Acacia aneura*) and *Eremophila gilesii* but also stimulate the germination of mulga seedlings. Any benefit from such a fire is thus likely to be short-lived. In this instance, a second fire may be needed to reduce the new generation. When the aim is to reduce the juvenile population of mulga, then a less intense winter burn is likely to be successful. Cooler burns can also protect some non-invasive species such as *Eremophila latrobei* that are susceptible to intense fires. The following paragraphs outline what is known about the use of fire for managing particular species.

Mulga (*Acacia aneura*)

Studies of cool season (low intensity) fires on mulga found that 80% of shrubs less than 2.75 m were killed while only 20% of taller trees were killed (O'Reilly 2001a). Such fires help in opening up the understorey for pasture growth. Cool season fires allow for summer grasses to establish whereas a hot summer fire may make way for winter herbage and grasses. In situations where much of the mulga has matured, an intense fire may be necessary to carry into the scrub. Purvis (1986) used intense fires on very hot days with strong north-westerly winds to burn dense woody areas that had minimal ground cover. This opened up the canopy and allowed for increased grass growth.

There is some concern from producers that burning mulga causes mass germination. It appears that this typically occurs with hot/intense fires (e.g. summer fires or at the bases of trees where litter fuel loads and seed levels are high (Griffin and Friedel 1984a)). It may be necessary to implement a second burn to thin these juveniles. Mulga can take 7 to 10 years to mature and set seed, which allows time to accumulate fuel to implement a follow-up burn (Allan et al. 2008). Generally speaking, fire-promoted germination is not widespread, but may appear so because it is visually quite dramatic (O'Reilly 2001b).

Witchetty bush (*Acacia kempeana*)

Little is known about this species in relation to fire. There are observations that it takes a hot fire to kill adult witchetty bush plants (Bastin 1987). Data from a cool winter burn showed 29% mortality in the species (O'Reilly 2001c).

Ironwood (*Acacia estrophiolata*)

Only one trial has been completed for thickets of juvenile ironwood and it was found that although the fire reduced the population, basal re-sprouting of plants was common (Griffin 1981). It appears that two fires in quite close succession would be necessary. The opportunities for this may be limited but are not impossible.

Broom bush (*Senna artemisioides*)

Broom bush has been reported as becoming very dense in some open woodlands (Friedel 1985). There is some evidence that both cool fires and intense fires can kill mature broom bush (Griffin and Friedel 1984a).

The implementation of a regime of prescribed burning to manage woody plant populations requires good planning. The emphasis should be on results achieved with a fire regime rather than on relying on individual fires to 'solve' a problem. Fires should be timed to suit the purpose for which they are intended rather than following a strict schedule. Consideration should be given to constant fire planning so that when fuel loads are adequate a timely response is possible.

The two things that prevent many producers from using fire are a lack of confidence in predicting the results/benefits and a fear that the fire will 'get away'. It is very difficult to forego short-term production gains from pasture growth in favour of burning for long-term land condition gain, particularly when rainfall is so unpredictable. It is also hard to know how effective a particular fire might be or how long the result will last, again because of seasonal variation. Regardless of these factors, there are many examples of using fire to influence vegetation throughout Central Australia and there are many ways of measuring success (O'Reilly 2001a).

Experience is the key to success so that producers can learn to judge where fires will carry and where they will naturally stop (O'Reilly 2001b). Conducting small burns in more "average" seasons will enable producers to gain some valuable experience whilst accessing training and support from such agencies as Bushfires NT. This experience can help when dealing with wildfires and planning larger controlled burns as a result of wetter seasons (O'Reilly 2001b).

5.5.4.3 Considerations/caveats

Ultimately, the post-fire pasture potential relies on grazing management that allows perennial pasture species to become well established (spelling may be required) and matching the stocking rate to the feed on offer (Friedel 1985; Bastin 1991a; Bull 2003).

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 hinders the recovery of desirable pasture species. In particular, it is important that palatable 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 they will have to be agisted or sold.

Modelling from the Alice Springs region shows that the economic benefits of prescribed burning may take more than 10 years to become apparent. For producers who are under pressure to achieve short-term animal production improvements, this time-frame may be a barrier to the implementation of a prescribed burning strategy.

As noted previously, fire can promote germination of some woody species, notably acacias. 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 these young plants set seed will reduce the build-up of seed-banks of such species as acacias.

An undesirable result is to burn available pasture but with such low intensity that no shrubs are killed. If a fire does not appear to be carrying then try again on a hotter, windier and/or drier day. Bushfires NT can help producers to assess appropriate burning conditions for specific purposes (Bastin 1987). Land managers have also recently found the North Australian Fire Information (NAFI) website (www.firenorth.org.au) to be invaluable in helping to plan and manage fire (G. Allan, pers. comm., 22 November 2011).

5.5.5 Essential management action 2: 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 plants. As outlined above, heavy grazing also reduces the opportunity for conducting prescribed fires by reducing fuel loads. Matching stocking rate to long-term carrying capacity increases the window of opportunity for incorporating effective fire into the management system. It also helps to maintain land condition and the important landscape processes that help maintain an appropriate shrub-grass balance.

5.5.5.1 Evidence supporting this management action

The GLM workshop (Chilcott et.al 2005) recommends at least 1000 kg/ha as the minimum fuel load for an effective fire for woody plant management and it is likely that this threshold will only be reached after very wet periods on some land types. There is evidence that two consecutive above-average summer rainfall seasons will produce the best opportunities for burning (Edwards et.al 2008). Grazing by feral and native herbivores can also impact on fuel loads available for burning.

As land condition declines from overgrazing, ground cover decreases, leading to an increase in run-off and erosion. Erosion can fundamentally alter natural drainage patterns, diverting water away from a landscape resulting in drying of the soil. Drier, less fertile soils cannot support a competitive ground cover and gradually become dominated by shrubs (Pringle and Tinley 2003). This issue is discussed in more detail in Section 5.4.2.

5.5.5.2 The implementation of this practice

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 areas requiring similar fire regimes are fenced together. Maintaining land condition is dependent primarily on stocking rates and the grazing strategies employed. Detailed information on stocking rate management can be found in Sections 5.2.4 and 5.2.5.

5.5.5.3 Considerations/caveats

Matching stocking rate to long-term carrying capacity increases the opportunities 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, which has the added benefit of reducing the costs of burning in terms of lost animal production.

It is inevitable that high fuel loads will develop in very high rainfall years and this will increase the risk of wildfires. Proactive management provides opportunities for producers to use these fuel loads for woody vegetation control whilst avoiding the undesirable impacts of uncontrolled wildfires.

5.5.6 Essential management action 3: implement pasture spelling

Even with pasture spelling, many land types in Central Australia will not grow enough fuel to carry a fire in an average season. The exceptions to this are spinifex and buffel grass land types. However, in above-average seasons, pasture spelling can enhance the potential for fuel accumulation. Spelling will also usually be required for managing post-fire recovery. 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) and allow palatable annuals to go to seed.

5.5.6.1 Evidence supporting this management action

See Section 5.5.4.2.

5.5.6.2 The implementation of this practice

The length of a pre-fire rest period necessary to facilitate fuel accumulation depends on soil moisture levels which are, of course, dependent on rainfall received. In poorer growing seasons and in lower rainfall zones even extended spelling may not be sufficient to accumulate the fuel loads needed in some land types. Occasionally, it may be possible to destock a paddock when it appears that a season has the potential to be very wet. Another scenario might be to destock after an above average rainfall year if it appears that the next one might be at least above-average. This can help ensure fuel loads are as high as possible.

5.5.6.3 5.5.6.3. Considerations/caveats

See Sections 5.5.4.3 and 5.5.5.3.

Issue 5
Bringing under-utilised pastures into production

Signs
Significant areas in larger paddocks receive little or no grazing and accumulate ungrazed pasture. Areas close to water may be overgrazed if stocking rates are based on total paddock area instead of watered area

Causes

Large paddocks with insufficient or poorly located water points

Recommended Management Responses

Develop water and/or paddock infrastructure

Essential Management Action 1

Install more water points in large paddocks

Evidence Supporting this Action

How to Implement this Practice

Considerations & Caveats

Complementary Management Action 1

Reduce paddock size

Evidence Supporting this Action

How to Implement this Practice

Considerations & Caveats

5.6 ISSUE 5: BRINGING UNDER-UTILISED PASTURES INTO PRODUCTION

Considerable areas of ungrazed palatable forage can often occur in large paddocks. In 2004 the average grazing radius from a watering point in the Alice Springs region was 9 km, with a range of 4 to 16 km (Leigo 2004). Research trials investigating the distribution of cattle suggest that better production can be achieved when cattle do not have to walk too far for food and water. At greater distances from water, stock cannot use all the pasture evenly and this unused pasture represents livestock production that is forgone by pastoral businesses. In contrast, areas near water often become degraded through overgrazing. Management options that create the opportunity for cattle to better use pastures distant from water have the potential to increase returns to the livestock enterprise by allowing more animals to be carried (where paddocks are currently stocked below the carrying capacity) or to spread the current grazing pressure more evenly. Where cattle numbers are increased, improvements in returns will come from increases in production per hectare. Where current grazing pressure is spread more widely, increased returns are likely to come from increased production per head.

Developing water point and fencing infrastructure on a property to improve grazing distribution is the primary management option to address this issue. Fire may sometimes have a role to play (in removing accumulations of old forage and improving grazing distribution) and pasture spelling may aid the recovery of previously overgrazed areas.

5.6.1 Signs

In large paddocks, significant areas of the paddock distant from water points receive little or no grazing. The areas near the water points that are subject to very high utilisation can be large and/or expanding quickly if stocking rates are based on total paddock area rather than the carrying capacity of the watered area of the paddock. This is certainly an issue in Central Australia where the average paddock size is larger than 300 km^2 (Leigo 2004).

5.6.2 Causes

The problem of having ungrazed areas distant from water principally arises in large paddocks with few water points where animals are unable to reach the distant parts of the paddock during daily foraging activities. Because cattle need to drink regularly (usually once a day) under the hot conditions experienced in Central Australia, this limits the distance from water that animals can graze. There is also a production benefit to be gained from minimising the amount of energy that cattle expend because walking diverts energy away from growth and maintenance of body condition. In addition to having insufficient water points, poorly located water points (in relation to factors that influence grazing distribution such as topography, shade or favoured areas) can also contribute to this issue.

Many people have seen cattle grazing at great distances (>5 km) from water. In winter, cattle may only need to drink once every two to three days and this may allow for a larger area to be used (Foran 1984). Furthermore, rain can sometimes provide surface water that allows cattle to graze well beyond 5 km of permanent water points. Cattle have also been known to travel long distances to access preferred land types that do not occur closer to water points. Nevertheless, it is usually only a very small proportion of the herd that is ever observed at large distances from water and the vast majority of grazing activity is confined to within 5 km of water.

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

The management questions that arise for pastures distant from water are:

a. What infrastructure development will give me the best return for my investment?

b. Do I need to build fences or can I just put in water points to improve grazing distribution?

c. When does it become cost-prohibitive to develop more infrastructure?

5.6.3 Management responses: develop water and paddock infrastructure

The most important management response involves making the areas of palatable forage accessible to cattle (i.e. all grazing areas are within easy walking distance of water) by establishing more water points. Improving the control over 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 increases the pasture available to cattle, it may be possible to increase the number of stock carried (provided the long-term carrying capacity of a paddock is not exceeded). If a paddock is already stocked at, or above, its safe carrying capacity, installing additional water points will not allow more stock to be carried in the paddock, but should help to distribute grazing pressure more evenly within the paddock. In turn, this can lead to increases in individual animal production due to the improved quality and quantity of forage available per animal (provided that stocking rates are matched to the long-term carrying capacity).

5.6.4 Essential management action 1: 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. Ideally, the maximum distance from water to palatable forage should not exceed about 3 km. Thus, to ensure reasonable levels of use in a large paddock, water points need to be separated by no more than about 5 to 6 km. A good rule of thumb is to allow one water point per 20 to 25 km^2 of land area (Hunt et al. 2010). Whether it is economic to develop water points this close in Central Australia is still open to debate and many producers in the region establish water points about 10 km apart.

5.6.4.1 Evidence supporting this management action

The notion that establishing more water points in ungrazed areas will increase the use of those areas is self-evident and 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 existing research. Most research on these issues has occurred in extensive regions (e.g. Central Australia and the VRD). Research in rangelands in the USA has also demonstrated that establishing new water points in under-utilised areas can increase grazing in those areas and reduce pressure on previously frequently-used areas.

Although a number of studies have reported the maximum distance cattle will walk from water to forage in northern Australia (e.g. up to 11 km on the Barkly Tableland and usually no farther than 5 to 8 km from water in Central Australia), most grazing by cattle occurs much closer to water. Grazing pressure usually declines markedly beyond about 3 km from water, although where water points are sparse, cattle will use areas farther from water. For example, on the Barkly Tableland (where water points are often separated by as much as 10 km or more) an assessment over a number of properties showed that about 55% to 60% of cattle activity occurred within 3 km of water and 80% to 90% occurred within 5 km of water (Fisher 2001). Although some cattle activity occurred farther from water, this was low, particularly at the extreme distances.

In a rotational grazing study undertaken at Mt Riddock Station, four of the paddocks had areas exceeding 3 km from water and the pastoralist observed that cattle spent most of their time grazing within 2 km of water (Materne 2010a). An important point to note is that the quality and quantity of feed was consistent at all distances from water in this study. Land condition and subsequent forage quality and quantity also impact on how far cattle will walk. Hodder and Low (1978) found that the majority of cattle grazed within 3 km of water under good forage conditions (green and abundant) and 4 km from water under moderate forage conditions (drying off and moderate abundance). They also observed that cattle (usually dry stock) were seen at great distances from water during drought.

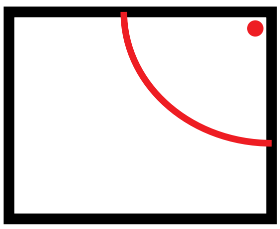
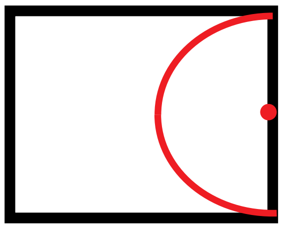
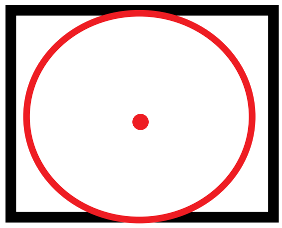
On Woodgreen Station north of Alice Springs, water points are placed as close as possible to palatable pastures. The philosophy is that small mobs spread out over numerous watering points reduce grazing pressure on the pastures and nutritional stress on the cattle (Purvis 1986). All classes of stock benefit from improved nutrition; for example, breeders will perform better through conception, pregnancy and lactation, steers will achieve better weight gain, bulls will be fitter (and in closer proximity to cows). Good hydration also helps reduce stress and maintain health. When animals are required to spend large parts of the day walking between food and water, intake declines and so does production. Pregnant and lactating cows require regular water and cannot walk too far for feed. If inadequate nutrition is available close to water, then breeder productivity can decline markedly. Furthermore, when breeders have to walk farther for feed, they leave their untended calves more vulnerable to dingo attack.

The limited evidence available suggests water points should be placed about 6 km apart (i.e. a 3 km grazing radius) in order to maximise carrying capacity. However, many producers do not think it is economically viable to construct a new water point unless it can carry an additional 300 head of cattle (White and Walsh 2010). However, it is unlikely that there are many land types in Central Australia that can safely carry that many animals within 28 km^2. Thus, for many Central Australian producers, further infrastructure development should probably be seen as an opportunity to spread current grazing pressure and improve per head animal performance rather than to increase numbers. For some properties, where only poorer land types are undeveloped, further infrastructure development to increase carrying capacity may not be economically viable. The high costs of water point installation and maintenance, and the productive potential of under-developed country are the main constraints to more intensive development (White and Walsh 2010).

5.6.4.2 The implementation of this practice

Where possible, water points should be sited away from fence lines and areas that cattle favour (e.g. creek lines, riparian areas) as this may help in reducing the extent to which cattle congregate around the water for lengthy periods and reduce the possibility that 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 the semi-arid rangelands of South Australia and WA have shown that grazing use within paddocks is more evenly distributed if water points are located away from fences. Although corner and paddock boundary locations for water points are preferred from a cost perspective, they create problems because they concentrate cattle in a smaller area and increase the effective stocking rate close to water (Table 12). This creates larger sacrifice areas around the water and can negatively impact on production because animals need to walk farther to access feed. A centrally-located water point dramatically increases the watered area of the paddock and results in lower effective stocking rates within 5 km of water (Table 12). If existing water sources (bores or dams) have sufficient capacity, water can be piped to tanks and troughs to provide water in areas without suitable dam or bore sites.

Table 12. An example of the impact of water point placement on the effective grazing area and stocking rate for a 100 km² paddock carrying 150 head

			
	Corner water	**Fence-line water**	**Central water**
Area within 5 km of water	20 km²	39 km²	79 km²
Stocking rate within 5 km of water	7.5 head/km²	4 head/km²	2 head/km²

5.6.4.3 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 variability of the land, the presence of permanent and semi-permanent surface waters, changes in land values and by management/maintenance considerations. In more developed regions (e.g. central Qld) water points are usually already closer than the recommendations. This is not so true in Central Australia where the high costs of drilling and equipping water points has constrained development. Where installing new water points 'opens up' new productive country to grazing, the investment is more likely to be worthwhile.

In a paddock that has multiple water points, cattle will not necessarily distribute themselves evenly amongst them. In very large paddocks, with large numbers of animals, this can result in congregations of cattle on certain water points. Some pastoralists manage to achieve a fairly even distribution of cattle across water points within paddocks, which may be because their stocking rate matches the feed available close to water and cattle do not need to forage farther afield to find nutritious pasture (Walsh 2009b; Walsh and Peatling 2012).

A trial conducted at Rockhampton Downs Station in the Barkly region investigated whether a more even paddock use could be achieved by rotating cattle between water points (Scott et al. 2010). In this trial, only one water point was in operation at a time in the 253-km² paddock. Early in the trial, the station manager found it difficult to change the behaviour of the cattle because they were used to having access to multiple water points when grazing in large paddocks. This resulted in cattle sometimes congregating at water points that were not in operation (Scott et al.

2010). Frequent checking and mustering was required to ensure cattle were kept on water, which made the system very labour-intensive. These issues were eventually overcome when the manager implemented a procedure of turning the next water point on and the current water point off the day before the planned move. The cattle learnt that this meant they were being moved to a new water point and ceased straying back to dry troughs (Scott et al. 2010). A system of successful water point management is also in operation at Alexandria Station in the Barkly region. The manager switches one or more water points off in large paddocks when he wants to spell the pastures around individual bores. Such a system allows spelling without the need to destock the entire paddock and works because there are multiple water points in each paddock and the bores are far enough apart (~5-6 km) to minimise grazing around the bores being spelled (Walsh and Peatling 2012).

It is important to note that despite having improved access to water, cattle will continue to graze paddocks unevenly to some extent. Techniques to attract cattle to under-utilised areas, such as the strategic location and regular re-location of supplements, and burning areas with old senescent pasture, may also help to distribute grazing more evenly.

The effect of installing additional water points 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 water points 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). A general recommendation is that up to 10% of a property should be set aside to conserve biodiversity (Biograze 2000).

5.6.5 Essential management action 2: reduce paddock size

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 of cattle preferences. Some water points may also be preferred so a large proportion of the herd may graze in areas near those water points. 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, particularly in areas where land type is highly variable in distribution and preference. However, because the financial cost involved can be substantial, it is often considered by local producers to be less attractive than establishing additional water points.

5.6.5.1 Evidence supporting this management action

Again, there is limited evidence from formal research on the effect of paddock size on grazing distribution and pasture use. The Pigeon Hole project in the VRD is the only project to have specifically investigated the effect of different paddock sizes. Using GPS collars to record cattle distribution in paddocks over six-month periods, 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 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 around a central water point, this would translate to a paddock size of about 36 km^2. In paddocks of this size at Pigeon Hole the herd generally used 80% or more of the paddock area compared with approximately 70% in larger paddocks where additional water 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. no smaller than 30 to 40 km^2) in the more extensive regions of northern Australia.

However, in contrast to this recommendation, one of the aims of an eight-paddock rotational grazing strategy at Mt Riddock Station was to achieve more even use of the pastures. The four smaller paddocks ranged in size from 3.1 km^2 to 6.4 km^2 and covered a total area of 20.5 km^2 while the four larger paddocks ranged in size from 10.2 km^2 to 13.5 km^2 and covered a total area of 46.6 km^2. Each group of four paddocks shared a water point. All of these paddocks achieved better evenness of use than the large continuously-grazed paddock nearby. In the larger rotation paddocks, it was observed that cattle rarely grazed beyond 2 km of water. In order to use the more remote parts of even these small paddocks, the producer intended to provide additional water (Materne 2010a). This study showed that greater evenness of use can be achieved by restricting cattle to a smaller, well-watered area but it did not provide any information as to the most effective paddock size. It should be noted that this study was conducted on relatively uniform buffel grass pastures.

5.6.5.2 The implementation of this practice

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. During the 1970s, investigations were undertaken to determine land type preferences of cattle in Central Australia (Hodder and Low 1978; Low et.al 1981). These studies covered over 500 km^2, on several stations and many land types. The results indicated that cattle mostly prefer woodland and floodplains, particularly during good forage conditions (e.g. green and abundant feed) during spring and summer. Foothill fans were used during moderate forage conditions (e.g. drying-off and moderate abundance) and particularly during winter. Areas dominated by less palatable perennial grasses were used after small rain events during dry periods as they quickly produced green shoots. Mulga annual pastures were used when pasture conditions declined further. When forage condition became poor (e.g. dry and sparse), cattle moved into the hills and mulga perennial areas.

Where possible, large areas of more preferred country can be fenced to allow for occasional spelling. This is particularly important given that cattle prefer to graze these landscapes when the pasture species are regenerating and setting seed immediately following rain. 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, stocking rates and subsequent monitoring of grazing impacts.

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 the paddocks are around 30-40 km^2) since this would further increase the extent of the watered area and reduce the potential for excessive overgrazing around water points (by reducing the number of cattle per water point). This approach also provides some safety and flexibility should one water point fail. Allowing one water point per 20 to 25 km^2 of land area is recommended to maximise the area accessible to cattle (Hunt et al. 2010). It should be noted that this is smaller than a local example of a successful enterprise that has an average paddock size of 67 km^2 (range 26 to 180 km^2) with all paddocks having multiple water points (Purvis 1986).

Where land types are uniform over large areas, it may be possible to use water points to control grazing distribution. On Lyndavale Station, south of Alice Springs, the owners have actually removed fences across a large area dominated by mulga woodland. This country is of relatively low productivity and fence maintenance was a high cost. This enterprise runs relatively low stock numbers per water point compared with the district average, and cattle have been found to stay on their designated water point because there is sufficient forage available. Additionally, water points are situated far enough apart to discourage cattle from congregating (Walsh 2009b).

Producers also find it advantageous to use smaller paddocks on highly productive country where good returns for fencing and water point development are more likely to be achieved. Smaller paddocks also provide opportunities for maintaining or improving land condition as spelling can be incorporated into the system. Small paddocks also provide for herd management activities, such as fattening steers or managing heifers separately from the breeder herd. These activities are recognised as best practice herd management techniques that have the potential to further increase profitability. On Umbearra Station, south of Alice Springs, steers being prepared for market have four paddocks ranging in size from 40 to 120 km^2 through which they are rotated depending on season, feed levels, stock numbers and the time of year (Walsh 2009d). On Narwietooma Station, north-west of Alice Springs, an extended rest grazing strategy is employed where cattle are rotated through paddocks ranging in size from 200 hectares to 300 km^2 (Walsh 2009c).

Producers have found that relatively small paddocks have additional benefits, such as cleaner musters, improved herd management (quieter animals, better identification of cow/calf relationships and increased bull/cow interaction), increased ease of rotation and a better understanding of pasture dynamics relative to grazing strategy used. Land condition changes are also more likely to become apparent in smaller paddocks (Stafford Smith et al. 2000) and may therefore be acted upon more quickly.

5.6.5.3 Considerations/caveats

Installation and maintenance costs are a major consideration when reducing paddock size. Fencing costs escalate rapidly for paddocks smaller than about 30 km^2, and paddocks smaller than this may be hard to justify solely on the grounds of improving grazing management. The development of new paddocks should occur on the most productive land first, where increased returns from development are most likely, or to protect sensitive areas of the landscape. Where it is not considered economic to fence, it may be worthwhile considering the installation of water points based on the principles discussed earlier.

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 burning.

As mentioned earlier, smaller paddocks do not automatically result in completely even use within a paddock. Some areas may still not receive much use and some areas will be heavily used. However, the rate at which overgrazed areas expand will probably be slower. As well as reducing paddock size, the use of other tools, such as the strategic placement of supplements or prescribed burning, should also be considered to improve grazing distribution in paddocks (see Sections 5.2.7 and 5.3.6).

6 KNOWLEDGE GAPS

Several activities undertaken during the NGS project (2009-12) identified knowledge gaps related to the science and management of stocking rates, pasture spelling, prescribed burning and infrastructure development. The following knowledge needs relevant to the Alice Springs region were identified through two workshops held in the region (White and Walsh 2010; Leigo and Walsh 2010) and discussions with DPIF staff. These gaps form the basis of ongoing grazing land management research and extension in the region. A long-term grazing trial has subsequently commenced on Old Man Plains Research Station near Alice Springs to directly address several of the gaps outlined below.

6.1 STOCKING RATES

1. Practical, robust pasture and soil indicators to allow producers to recognise when stocking rates need to be reduced to avoid lasting damage to pastures and soils.

2. A long-term demonstration site investigating the practical aspects of matching stocking rate to carrying capacity (e.g. forage budgeting).

3. Cost-effective options for managing feral and native herbivores.

4. The development of more reliable seasonal forecasting tools.

5. The development of a methodology for determining stocking rates in paddocks to accommodate the variability in land type preference and minimise overgrazing of highly-preferred areas.

6. The development of new models to facilitate modelling of a variety of land types within one paddock.

7. The reduction of cattle numbers to a safe stocking rate to assess long-term results with regard to productivity and land condition.

8. The investigation of ways to increase productivity within the current business model (e.g. decreasing stocking rate by culling underperformers to increase average herd productivity).

9. An analysis of how a more productive herd might allow lower stocking rates and how this might provide opportunities for such activities as land restoration, spelling and burning.

10. Ongoing validation of the links between soil fertility/land condition, pasture quality and grazing management.

6.2 Pasture Spelling

1. Research to predict the pasture growth and recovery responses that can be achieved using the most promising pasture spelling regime(s) identified for the region, particularly to recover C condition country. One promising option identified is a paired-paddock system, where all stock are grazed in one paddock while the other is spelled for a year.

2. Fine-tuning the mathematical functions in GRASP to improve the realism of land condition recovery responses (i.e. be able to simulate the initial lag in response, which is typical under real conditions).

3. Practical, robust indicators to allow producers to assess when pastures have been adequately spelled and grazing can re-commence.

4. Reliable information on the costs and benefits of various grazing and spelling strategies.

5. Increasing the understanding of how different land types respond to spelling in terms of response and time taken to achieve outcomes.

6. Definitive proof of the costs and benefits of spelling and how long it will take for land condition to recover.

7. Practical strategies for incorporating spelling (i.e. land type, frequency, duration, routine vs. opportunistic).

6.3 Landscape Restoration

1. Determining the increase in pasture growth as a result of using ponding banks in order to inform the modelling of responses in GRASP.

2. Demonstrating extensive rehabilitation in different land types and climates.

6.4 Prescribed Burning

1. An improved understanding of the interactions between grazing, fire and rainfall and their impact on pre-fire and post-fire pasture dynamics, animal production and business performance.

2. Recommendations on the best pre-fire and post-fire management actions under different seasonal conditions.

3. How to better manage feral and native herbivore grazing on burnt areas.

4. The development of methodologies and training opportunities to increase producer confidence and skills to effectively and safely burn country.

5. Research on the likely outcomes and potential management activities required if post-fire results are not highly desirable (e.g. a lack of rain leaves the soil bare and vulnerable to erosion or the fire did not burn with an intensity necessary to achieve required results).

6. An analysis of the costs associated with fighting wildfires compared with using preventative prescribed burning techniques.

6.5 INFRASTRUCTURE DEVELOPMENT

1. How to improve the uniformity of grazing within paddocks without the need for more fencing (e.g. using such tools as strategic placement of supplements to manipulate grazing behaviour, turning water points on/off).

2. Research on the pros and cons of new technologies (e.g. telemetry, walk-over weighing, rotational grazing strategies) on animal behaviour and production.

3. Determining the appropriate level of infrastructure development for the region to optimise animal production and profitability.

4. An economic analysis of the costs, handling efficiencies and animal performance benefits of using laneways to muster and move cattle.

5. Improved understanding of the impact of infrastructure development on per head and per hectare productivity.

6. Behavioural aspects of cattle in relation to water points (e.g. understanding their fidelity to specific water points and how to increase the use of alternative water points whilst minimising production penalties and management costs to keep them on specific water points).

7. How to best manage grazing distribution using multiple water points and less fencing.

8. Tools to help producers develop plans for paddock subdivision and/or new water points which include likely outcomes for animal production, economic performance, break-even timelines and land condition.

9. Technological advances in the use of water medicators and remote watering monitoring and their application in Central Australia.

10. The development of cheaper alternatives for constructing new watering points.

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