BEST-BET PRACTICES FOR MANAGING GRAZING LANDS IN THE BARKLY TABLELAND REGION OF THE NORTHERN TERRITORY

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

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Bibliography:

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1 INTRODUCTION

This technical guide has been written to help inform and improve grazing management in the Barkly Tableland region of the Northern Territory (NT). It focuses on four major themes: managing stocking rates, spelling pastures, prescribed burning and property infrastructure development. The guide is intended as a technical resource for use by 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 NT Department of Resources (now the Department of Primary Industry and Fisheries (DPIF)), the Queensland (Qld) Department of Employment, Economic Development and Innovation 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).

2. Outputs from testing different management options via 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 via 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 manage woody vegetation thickening (Section 5.4).
- How to most cost-effectively bring under-utilised pastures into production (Section 5.5).

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 these.
- 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 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 via 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 BARKLY REGION

The Barkly region is more than 240 000 km² in size and is situated in the central part of the NT abutting the Qld border (Bubb 2004). The region has a semi-arid monsoonal climate and experiences two distinct seasons. The wet season occurs from October to April and the dry season from May to September. Rainfall is highly variable from year to year, but there is a gradient of decreasing mean annual rainfall from the north (in the Gulf district) to the south (near Tennant Creek).

The main vegetation types in the region include *Eucalyptus* and *Acacia* woodlands with tall-grass understoreys in the north (i.e. the Gulf district) and spinifex grassland understoreys in the south (i.e. Tennant Creek district), treeless cracking clays supporting productive Mitchell and Flinders grasslands (i.e. Barkly district) and various shrublands and open woodlands (Bubb 2004).

Ownership is a mix of large corporate companies, large family companies and smaller family holdings. The average property size on the Barkly is about 6750 km², with corporate properties tending to be bigger than privately held ones (Bubb 2004). Herd sizes range from about 1000 to more than 20 000 head (Bubb 2004). When producers were asked to nominate a current carrying capacity for their property in 2004, the average varied depending on district and ranged from about 14 500 adult equivalents (AEs) in the Gulf and Tennant Creek districts and about 32 200 in the Barkly district (Bubb 2004). Many producers felt that there was capacity to increase herd sizes on their properties with further water point development.

The majority of properties in the Barkly region are breeder operations, but some properties also fatten stock. Brahmans are the dominant breed (70% of properties), with Santa Gertrudis, Brahman crosses, Composites, Wagyu and Angus making up the remainder (Bubb 2004). There is an ongoing trend towards improving animal performance through genetics, cross-breeding and improved husbandry practices. The predominant markets targeted by Barkly producers are live export, abattoirs, re-stockers and backgrounders. Qld and South-East Asia are the most significant destinations by number for Barkly cattle (Bubb 2004).

Barkly properties have relatively large paddocks (average of 150 to 360 km² depending on district) and the average paddock number per property is between 12 and 24 (Bubb 2004).The average number of man-made water points per property is about 55 and producers surveyed in 2004 thought that the minimum upper limit distance to water should be 3 to 5 km and the maximum upper limit 8 to 12 km (Bubb 2004). Water point development and paddock subdivision are high priorities for many producers; however, costs are limiting the rate of development for many.

Continuous grazing is the most common strategy, but other approaches, such as rotational systems and wet season spelling, are also used (Bubb 2004). The typical approach to managing stocking rates is through trial and error and experience rather than formal assessments of carrying capacity or forage budgeting.

Some producers in the Barkly region conduct prescribed burning. The reasons for burning include controlling weeds, freshening up pasture, removing rank grass, manipulating grazing behaviour and opening up country for mustering (Bubb 2004). About half of the producers in the Barkly region have noticed an increase in woody vegetation on their properties and the majority of these consider it to be a concern due mainly to the impact on mustering, but also on pasture growth and quality (Bubb 2004).

5 GUIDELINES FOR GRAZING MANAGEMENT AND PRESCRIBED BURNING

5.1 INTRODUCTION

The following sections specifically address four 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 Barkly 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 a paddock. • Exacerbated by drought and/or intense/frequent wildfire events.
3. 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.
4. 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

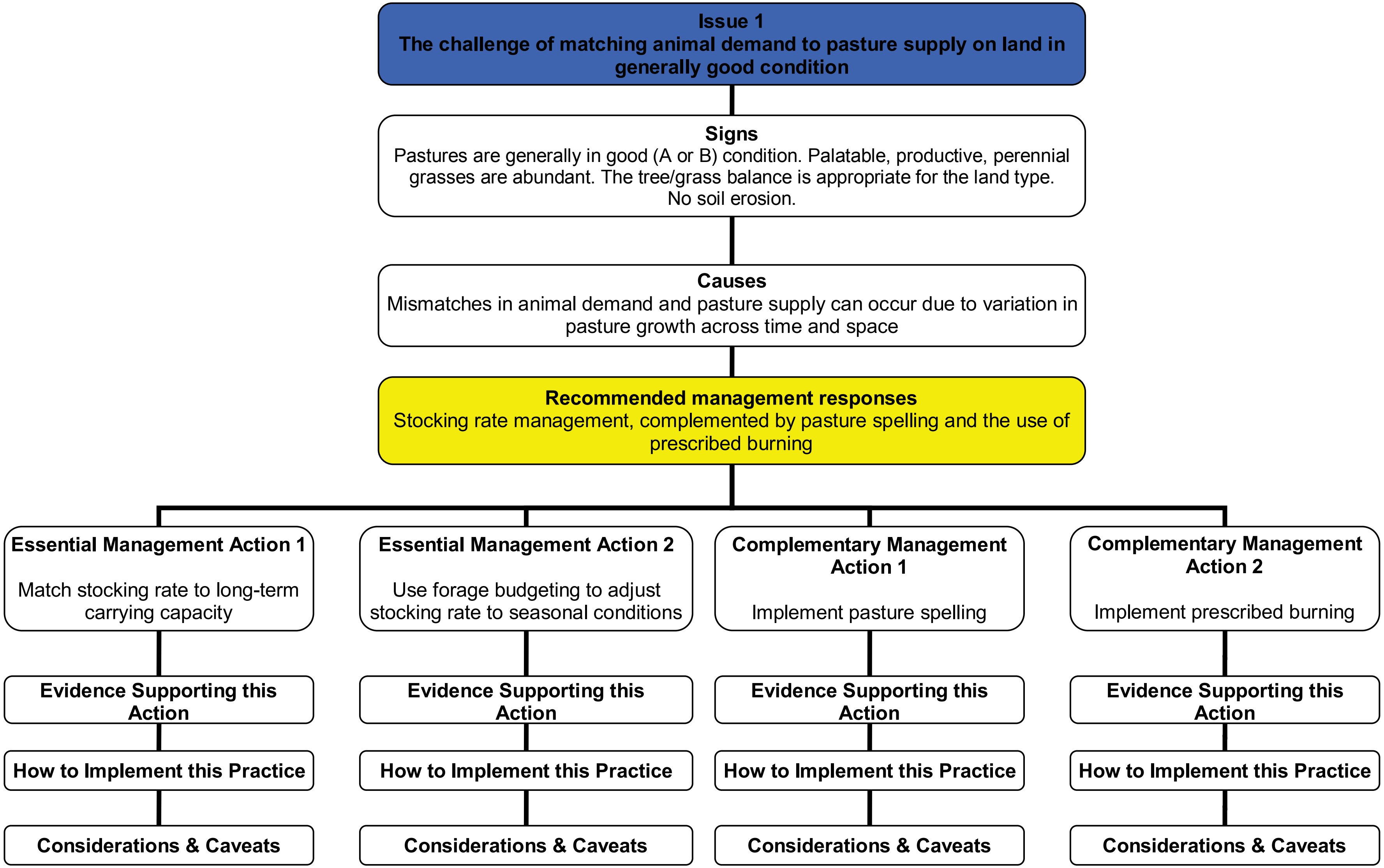


Figure 1. Diagrammatic representation of how this technical guide is structured, using "The challenge of matching animal demand to pasture supply on land in generally good condition" as an example issue

5.2 Issue 1: The challenge of matching animal demand to pasture supply on land in generally good condition

Much of the grazing land in northern Australia is in good condition (A/B on the ABCD scale – see Chilcott et al. (2005). NT Pastoral Land Board figures indicate that about 88% (n=77) of Tier 1 monitoring sites in the Barkly district and 67% (n=28) of sites in the Tennant Creek district were in good or fair land condition in 2007-08 (Pastoral Land Board 2010). A major challenge facing producers is how to optimally use this feed for animal production, while at the same time maintaining good land condition. In good years, high stocking rates can increase animal production per hectare, but in poor years high stocking rates can result in poor animal production and degraded pastures.

The amount of feed grown each year can vary widely due to the timing and amount of rainfall, so the appropriate number of animals to utilise the feed also varies widely. In theory, it would be desirable to change animal numbers each year so that the feed demand by animals matches the feed supply from the pasture. In this way, overgrazing and subsequent pasture deterioration during periods when pasture growth is low, are avoided and animal production increases in years with high pasture growth. However, this is not 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 in a breeding enterprise.

5.2.1 Signs

The pastures in this scenario are generally in A or B condition. This suggests 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, with ample feed for the whole year in good years, adequate feed for the whole year in average seasons and possibly inadequate feed towards the end of the year in poor years. 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 continued over a period of years, the average land condition moves from A/B to C.

5.2.2 Causes

By definition, producers with 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 AEs comes about by selling animals (sale steers, surplus heifers, cull cows), producing calves, buying animals (bulls, heifers, stores), 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 vary between years due to variations in the breeding, retention, mortality and selling rates, and the timing of sales. For example, delaying the sale of steers and cull heifers by just two to 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 producers 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 pasture growing conditions are a major cause of mismatches between feed supply and animal demand, they are largely outside the control of producers; the most effective management response is therefore to adjust the stocking rate (the demand side of the equation). Pastures can also benefit from complementary practices, such as spelling and/or prescribed burning. Spelling can be used to increase the quantity of the pasture 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 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). 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 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 rainfall 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 (Johnston et al. 1996). 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. In the Barkly region, stocking rates that achieve up to 20% to 25% utilisation of yearly pasture growth on black soils, 10% to 15% on red soils and 5% on spinifex-based pastures are considered to be ecologically sustainable. Grazing studies in Qld and the 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.

In regions where rainfall is relatively predictable (such as the Barkly and the Victoria River District (VRD)), 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).

5.2.4.1 Evidence supporting this management action

A recent study calculated average utilisation rates for several Mitchell grass paddocks in the Barkly region (Walsh and Cowley 2011). The assumption underpinning the work was that paddocks that are in good land condition must have been managed using sustainable utilisation rates. Using pasture growth estimates from GRASP, together with detailed stock records, the average utilisation rate over the past ten years was calculated for the watered area in each paddock. Average utilisation rates for the study paddocks ranged between 19% and 45%. The paddocks that had the best land condition were those with average utilisation rates ≤25%. At average utilisation rates above this, there was evidence of a decline in land condition and areas of preferred country (such as bluebush swamps) were receiving unsustainable levels of grazing. The sustainable utilisation rates found for the Barkly are consistent with the findings of two grazing studies on black soils in the VRD. In a trial at Mt Sanford Station, utilisation rates of up to 23% were found to be sustainable over the medium term on fertile black cracking clays in evenly-grazed paddocks in fair to good condition (Cowley et al. 2007; Hunt et al. 2010). The second grazing study, at Pigeon Hole Station in the VRD, was also conducted on fertile black cracking clay soils. The Pigeon Hole paddocks tended to be in C land condition and the optimum utilisation rate for balancing land condition and animal production targets was found to be 19% (Hunt et al. 2010). Average utilisation rates between 13% and 17% had positive or stable trends in species composition and ground cover whilst an average utilisation rate of 24% failed to meet some important yield and cover targets at Pigeon Hole (Hunt et al. 2010). A higher average utilisation rate (32%) resulted in the greatest decline in land condition, negative trends in species composition and an increased risk of unacceptably low ground cover levels (Hunt et al. 2010).

At Mt Sanford, the stocking rates that achieved a utilisation rate of 23% ranged between 19 and 23 AE/km², depending on the season. At Pigeon Hole, the stocking rates required to achieve a 19% average utilisation rate ranged between 9 and 17 AE/km². The considerable variation in the stocking rates required to achieve a desired utilisation rate at Pigeon Hole and Mt Sanford reflects the effect of seasons and land condition on carrying capacity (Hunt et al. 2010). In the Barkly study, utilisation rates of 20% to 25% were achieved with average stocking rates ranging between 3 and 6 AE/km² which is a reflection of the lower pasture growth experienced in the Barkly region (Walsh and Cowley 2011). The available evidence thus supports current recommended utilisation rates of 20% to 25% for pastures on fertile black cracking clays in the Barkly and the VRD.

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. Most studies on intensively-managed sown pastures have shown a linear decline in animal production per head with an increase in stocking rate (Figure 2; Jones and Sandland 1974) but Ash and Stafford Smith (1996) suggested that animal production in rangelands is less sensitive to this trend due to a much greater spatial and temporal variability. There is some evidence to suggest that the stocking rates applied in northern Australian grazing trials have not been high enough to identify the peak and subsequent decline in production per hectare. This may reflect the seasons experienced during the studies or the relative insensitivity of animal production to stocking rate in extensive native pastures.

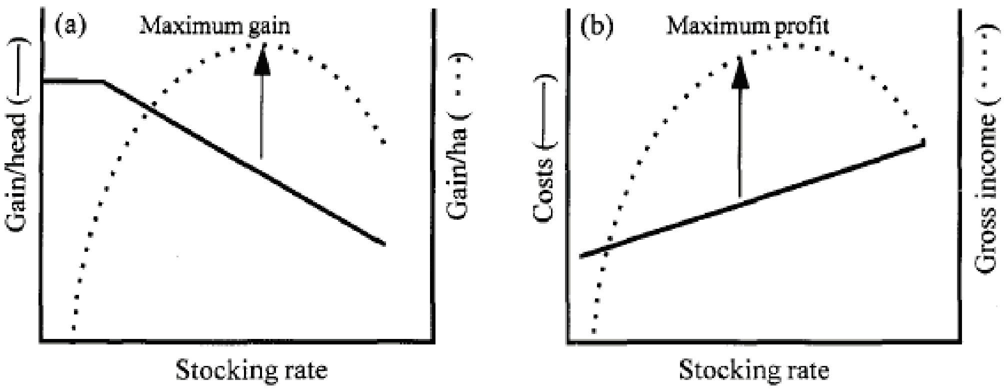


Figure 2. (a) The Jones-Sandland model relating livestock performance to stocking rate, (b) the relationship between stocking rate and economic performance based on the Jones-Sandland model (from Ash and Stafford Smith 1996)

The lack of large stocking rate or utilisation rate trials in the Barkly means that there is no evidence to assess whether these relationships hold true in this region. However, the observations are supported by the findings of other trials in the NT. For example, despite declines in individual animal performance at Mt Sanford in the VRD, earnings before interest and tax per unit area were still higher in the high utilisation rate paddocks due to increased turnoff (Hunt et al. 2010). At first glance, the Mt Sanford data suggests that there is little incentive to run conservative stocking rates. However, the Mt Sanford trial was conducted during a run of above-average rainfall years. Production results after the one poor wet season of the trial (2002-3) indicated that the higher utilisation rates were not environmentally or economically sustainable. Weaning percentage declined at higher utilisation rates after the poor wet season and took two years to recover (Hunt et al. 2010). Production was also more variable through time at higher utilisation rates. Production indices that performed better at lower utilisation rates included breeder weight, inter-calving interval and kilograms of weaner produced per area (Hunt et al. 2010). Thus, breeder herds in the VRD can maintain high weaning rates at high utilisation rates provided seasonal conditions are favourable. However, once seasonal conditions deteriorate, breeders may be unable to maintain calf output, resulting in lower weaning rates.

Similarly, in the Pigeon Hole trial in the VRD, there was a 14% decline in individual animal production with a doubling of utilisation rate (Hunt et al. 2010). Like at Mt Sanford, however, the decline in per head production was offset by increased per hectare production (and thus profit) at higher stocking rates. Inter-calving interval, steer live-weight gain, branding rate and weaning rate were not correlated with the utilisation rate. Only weaner weight (which directly influences weight weaned per hectare) was impacted by the utilisation rate at Pigeon Hole (Hunt et al. 2010). At a utilisation rate of 13%, the proportion of cows pregnant and lactating was slightly (but not significantly) higher and calf losses were about 3% lower than at higher utilisation rates. So, whilst there appeared to be little production penalty in implementing higher stocking rates over the relatively good seasons experienced during the trial, the lower weaner weights may have a hidden cost in that turn-off times for steers may be longer and heifers may take longer to reach joining weight. Furthermore, the negative impacts on land condition described above would be expected to have negative production impacts over the longer term, particularly when poorer seasons occur. In the Pigeon Hole trial, stocking rates were adjusted to reflect the forage supply in May each year. This annual adjustment of stocking rate to track forage supply is likely to have dampened the impacts of higher utilisation rates on animal performance compared with a set-stocked regime at similar stocking rates (R. Cowley pers. comm.).

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

Impact of stocking rate management on land condition

Unfortunately, the grazing research as a whole does not provide a consistent message in relation to stocking rate management and its impact on profit and land condition. In part, this is probably because most trials have been run for too short a time (<10-15 years), and pasture systems probably have a certain degree of resilience to change. Some trials did not trigger much change in land condition even at their highest level of grazing pressure (which varied over time in many cases). Several trials have shown that higher than recommended utilisation rates can result in greater productivity and profitability, although this appears to only hold for sequences of above-average rainfall years (McIvor et al. 2010).

Given the uncertainty surrounding stocking rate management and the economic temptation to run higher stock numbers, it is not surprising that producers in the region have recently asked whether it is fine to “stock up” for short periods (one to two years) to generate extra cash-flow to meet financial commitments. The available evidence suggests that if the area in question is in good condition and the usual stocking rates are close to the long-term carrying capacity, then some flexibility in stocking rate is possible, and even desirable. GRASP simulations for the Barkly (Figures 3 to 5) show that for producers wanting to move from low to moderate stocking rates, some level of annual stocking rate adjustment to match pasture supply will be needed in order to maximise animal production and maintain good land condition. The higher the target stocking rate, the higher the flexibility in numbers has to be to maintain good land condition. Research trials and bio-economic modelling show that the transition from a good year to a poor year is the most critical time for impacting on long-term land condition, so stock numbers may have to be reduced quickly if the season is poor under a higher stocking rate strategy.

It should be noted that in order to implement a short-term increase in stocking rates on country in **C condition**, a program of wet season spelling will probably be required in order to improve land condition and maximise animal performance (see Section 5.3.4).

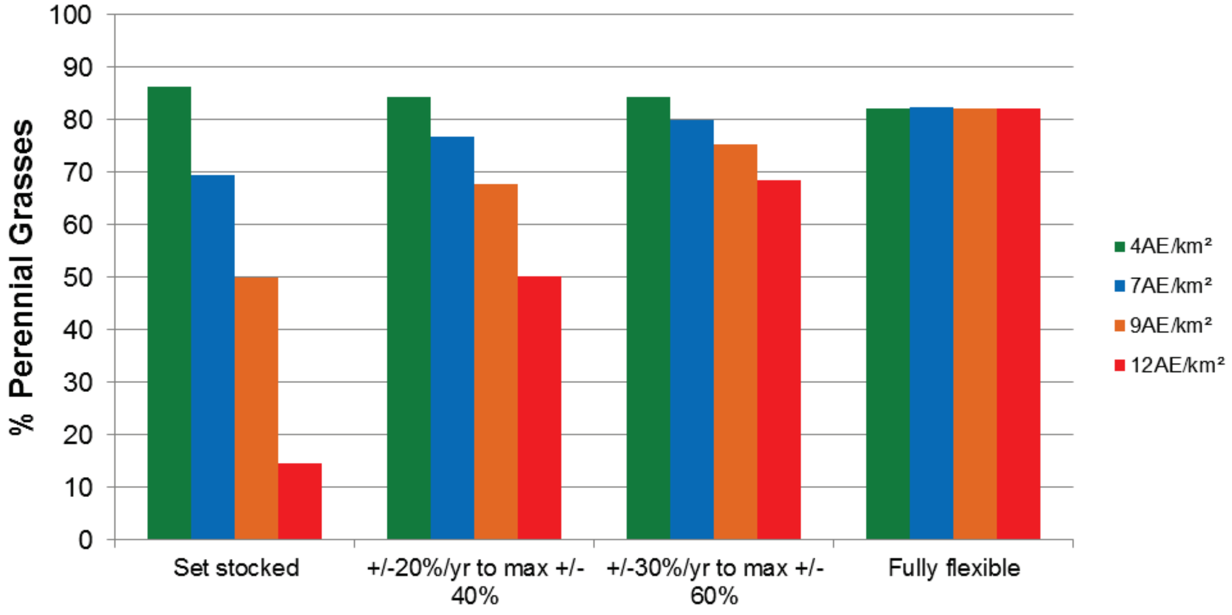


Figure 3. GRASP simulation showing the impact of stocking rate strategy on land condition for a grey cracking clay in the Barkly starting in B land condition. Percentages perennial grasses are used as a proxy for land condition (A condition ≥84%, B=32-83%, C=6-31%, D≤ 5%). Target stocking rates are shown in the legend, with 4 AE/km² considered low, 7 low-moderate, 9 safe and 12 high. Note that the 'safe' stocking rate is defined as the stocking rate which achieved an average of no less than 50% perennials over the long-term simulation period. This may or may not be indicative of a safe stocking rate on actual properties. The flexibility scenarios shown on the x-axis are no flexibility (set stocked), +/-20% per year to a maximum of +/-40% over the simulation period, +/-30% per year to a maximum of +/-60% over the simulation period and fully flexible (stocking rates could vary as much as needed to closely track the pasture supply).

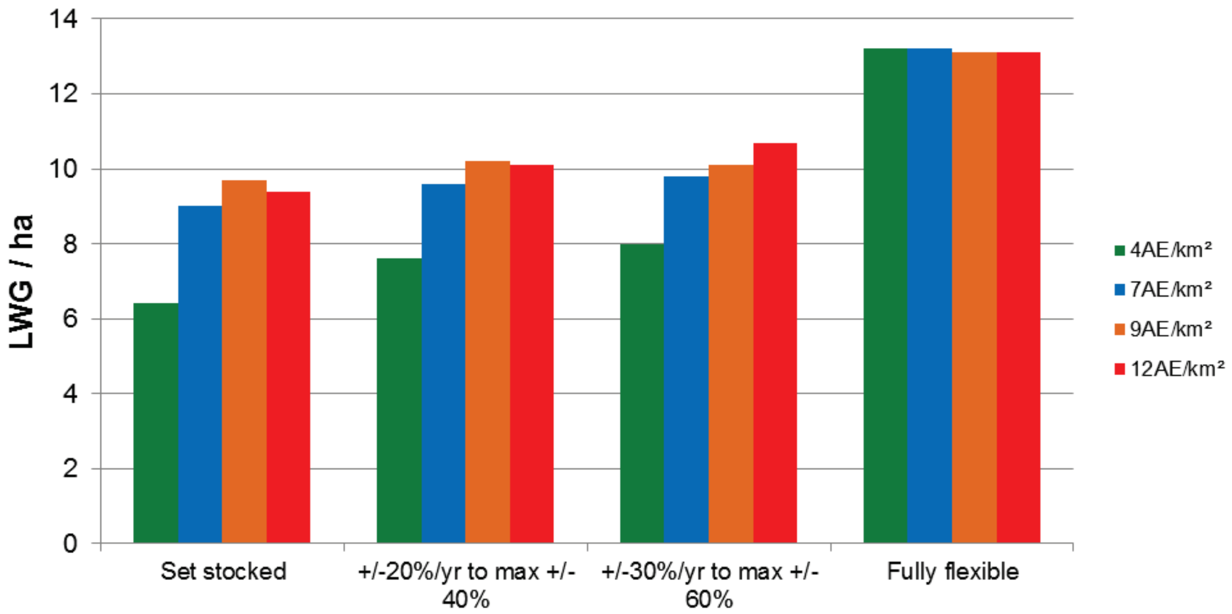


Figure 4. GRASP simulation showing the impact of stocking rate strategy on live-weight gain per hectare on a grey cracking clay in the Barkly starting in B land condition. Stocking rate flexibility scenarios are as in the previous figure. Increasing flexibility generally improved live-weight gain per hectare for any given stocking rate.

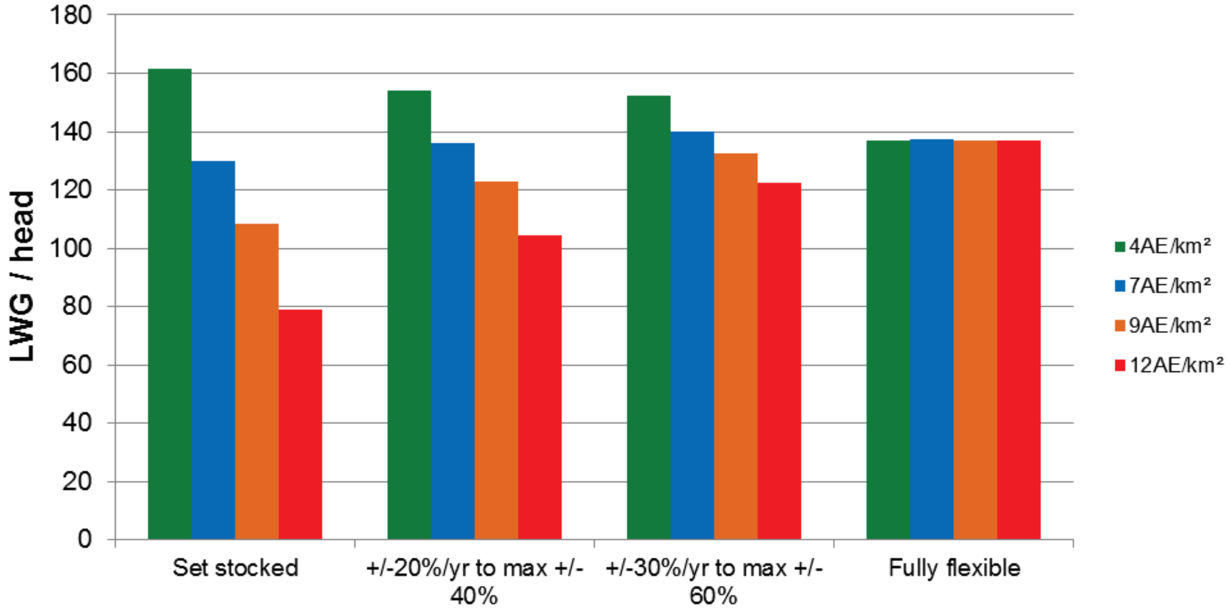


Figure 5. GRASP simulation showing the impact of stocking rate strategy on live-weight gain per head on a grey cracking clay in the Barkly starting in B land condition. Stocking rate flexibility scenarios are as in the previous figures. Live-weight gain per head was generally better at lower target stocking rates, but increasing stocking rate flexibility did buffer higher stocking rates to an extent.

5.2.4.2 The implementation of this practice

In the Barkly region, where the timing and amount of rainfall is relatively predictable compared with more arid areas, sustainable carrying capacities are typically based on the pasture growth that would be expected in at least 50% of years (i.e. the long term median pasture growth).

DPIF recently calibrated several parameter files to model pasture growth in the Barkly region using the GRASP model. As a result, it is possible to produce median pasture growth estimates for several land types with a high degree of confidence. Together with evidence-based recommendations for sustainable utilisation rates, carrying capacities can be calculated for properties in the Barkly 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 a 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 (James and Bubb 2008). In the Barkly, actual stocking rates should be calculated based on the carrying capacity of the land within 5 km of water (see Section 5.5.4.2).

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). Furthermore, urea supplementation increases feed intake during the dry season by as much as 20% (Winks et al. 1970; Winks and Laing 1972; NT Government 2009) and must be taken into consideration when determining feed demand. DPIF can provide advice on calculating AEs from raw stock numbers or producers can learn how to do this by attending a GLM course.

Finally, any grazing pressure from feral and native herbivores needs to be taken into account when calculating stocking rates (see Chilcott et al. 2005 for appropriate conversions).

5.2.4.3 *Considerations/caveats*

Care needs to be taken if the land types within a paddock vary widely in the palatability of their pasture species, land condition and/or productivity. Small areas of preferred country can be subjected to stocking rates orders of magnitude higher than the average for the paddock. Producers need to monitor the land condition of these preferred patches 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.

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. set stocking at the carrying capacity), there will be years where 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). Figure 6 demonstrates the negative impact that set-stocking can have on land condition during runs of average to below-average rainfall years. It also shows the rapid improvement in land condition that can be achieved using such a strategy in runs of better seasons. The simulation indicates that stocking rates can be increased above the long-term carrying capacity in good seasons to take advantage of above-average pasture growth with lower risk of harming the pasture, but prompt action is required to reduce stocking rates as pasture availability and seasonal conditions decline. Figure 6 shows that for the flexible stocking rate options, early land condition improvements tended to coincide with good rainfall years. In these years, stocking rates were allowed to rise to track the forage supply but when a poor wet season followed good seasons, declines in land condition often occurred. Such declines in land condition can persist for many years and impact negatively on pasture productivity, animal production and profitability.

If stocking rates are allowed to “creep up” over a period of favourable seasons, a below-average wet season can lead to overgrazing of the preferred perennial grasses and a decline in ground cover levels. In this situation, stocking rates will need to be reduced back to levels consistent with the long-term carrying capacity. In the case of a total failure of the wet season or consecutive poor years, stocking rates may need to be reduced below the long-term carrying capacity in order to protect pastures from long-term damage. Plans for a progressive reduction in stocking rates during deteriorating seasonal conditions should be developed to avoid crisis management. Adjust stocking rates at least twice a year if necessary (i.e. at the start of the dry season and then again later in the dry season during normal mustering operations). Where it is feasible, reducing stocking rates during the wet season if rains are poor can help protect land condition.

Stocking rate decisions should be based on an assessment of current pasture conditions. This should consider patterns of grazing distribution within paddocks. 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 wet season. In the Barkly, producers have little confidence in seasonal forecasting (White and Walsh 2010) and estimates of expected pasture production based on historical records are typically used instead (Chilcott et al. 2005). 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.

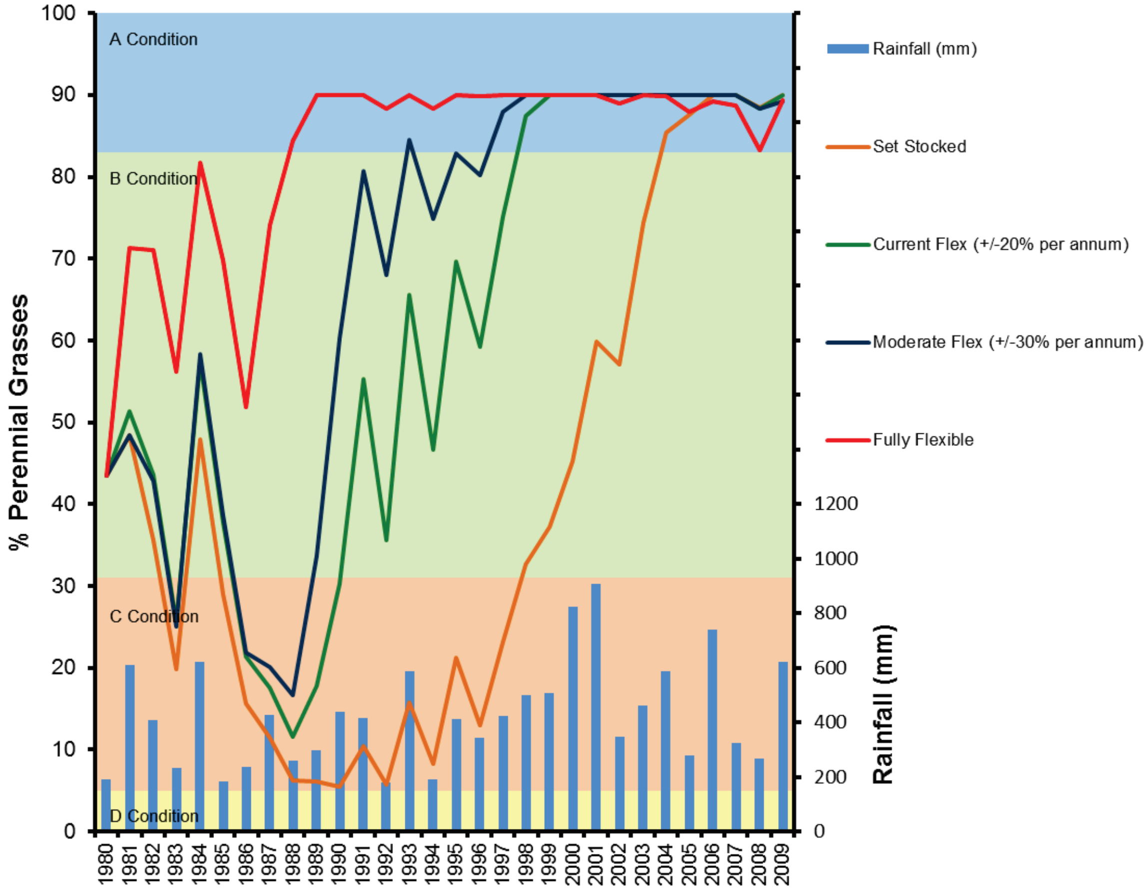


Figure 6. GRASP simulation showing the impact of various flexible stocking rate strategies on land condition for a grey cracking clay on the Barkly, starting in B condition for the period 1981-2009. Percentages perennial grasses are used as a proxy for land condition. For a target stocking rate of 7.5 AE/km², higher stocking rate flexibility resulted in the maintenance of good land condition during this time period. Set stocking led to a major decline in land condition in the poor rainfall years from the mid-1980s, which was only able to recover due to a run of good seasons in later years. Having some stocking rate flexibility helped land condition to improve after the late 1980s. The flexibility options shown are: set stocked (same stocking rate for whole simulation regardless of season), current industry flexibility (+/-20% per year to a ceiling of +/-40% across the simulation), moderate flexibility (+/-30% adjustment of stock numbers per year to a ceiling of +/-60% across the simulation) and fully flexible (unlimited flexibility to track the seasons).

5.2.5.1 Evidence supporting this management action

The Wambiana trial in Qld tested the economic and land management implications of variable stocking rates where animal numbers were changed each year at the end of the growing season. The variable stocking regime 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. Bio-economic modelling from the Barkly indicates that a moderately variable stocking regime can result in higher profits than a set-stocked regime (Figure 7 and Table 2). In this particular time window, the set stocked scenario led to economic losses in more years due to the influence of poor pasture growth and declining land condition on animal performance. The fully flexible option, which is impractical to implement in the Barkly, experienced more years with negative profits than other flexibility options because large numbers of cattle needed to be removed in poor seasons.

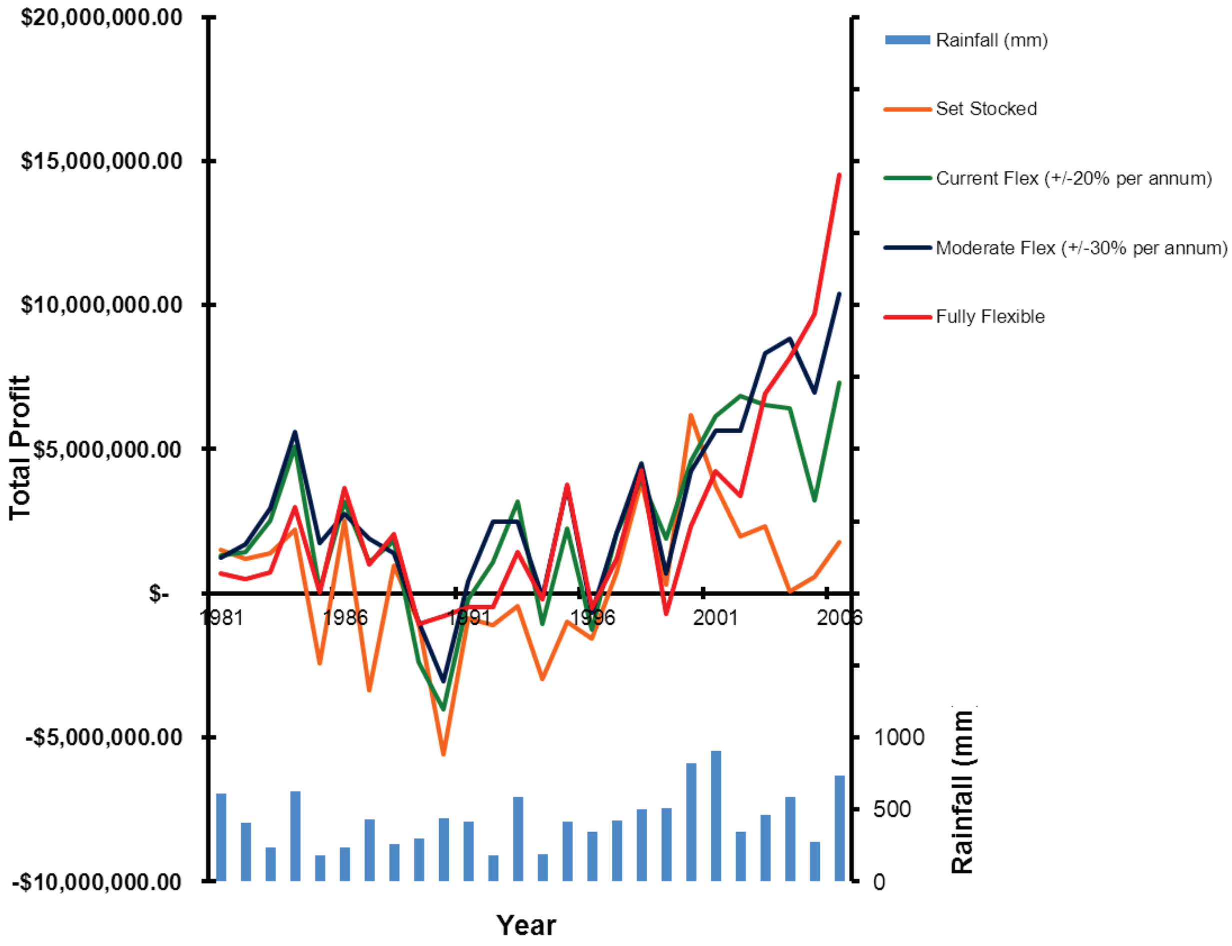


Figure 7. ENTERPRISE simulation of total profit versus stocking rate flexibility options for a central Barkly representative property of 6000 km² running about 16 000 breeders (1981-2006). The flexibility options shown are: set stocked (same stocking rate for whole simulation regardless of season), current industry flexibility (+/-20% per year to a ceiling of +/-40% across the simulation), moderate flexibility (+/-30% adjustment of stock numbers per year to a ceiling of +/-60% across the simulation) and fully flexible (unlimited flexibility to track the seasons).

Table 2. Summary of simulated total profit for the above central Barkly representative property under various stocking rate flexibility scenarios (1981-2006)

	Stocking rate flexibility strategy			
Profit measures	**Set stocked**	**Current industry flexibility**	**Moderate flexibility**	**Fully flexible**
Average	$425 511	$2 432 235	$3 113 302	$2 590 609
Minimum	-$5 581 690	-$4 025 154	-$3 063 250	-$1 053 697
Maximum	$6 190 324	$7 332 784	$10 377 700	$14 516 361
No. years negative	10	5	4	7
Net present value @ 4%	$4 295 659	$32 615 166	$42 071 073	$31 784 160

Although the Wambiana trial showed there was potential to make more money by taking advantage of a run of above-average rainfall 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 variable stocking strategy, particularly for breeder operations. The preliminary bio-economic modelling presented above also provides some support for the current level of stocking rate flexibility that is typically applied by Barkly producers.

The Mt Sanford and Pigeon Hole grazing trials also provide some information on the issue of adjusting stocking rates to closely match pasture growth. As mentioned previously, considerable adjustment of stocking rates was required to achieve target utilisation rates in these trials due to seasonal and land condition effects. For example, at Mt Sanford (B condition), annual stocking rates in the optimal utilisation treatment (23%) ranged between 12 and 23 AE/km² (average 18 AE/km²). At Pigeon Hole (C condition), stocking rates in the best performing utilisation treatment (19%) ranged between 13 and 20 AE/km². At times, the researchers involved in the Mt Sanford and Pigeon Hole trials found it challenging to achieve set utilisation rates within treatments due to practical issues. At Mt Sanford, adjusting stock numbers following forage budgeting in April was more successful than the approach used at Pigeon Hole. At Pigeon Hole, stock numbers were adjusted following pasture growth modelling, rather than field based forage budgeting and this sometimes led to insufficient cattle being added to the paddocks (Hunt et al. 2010). Sometimes there were also delays in adding cattle following good seasons, which meant that target utilisations were sometimes not achieved in high rainfall years. It is likely that producers would also face practical limitations in adjusting stock numbers to closely match forage supply. Achieving clean musters in heavily-timbered paddocks and ensuring adequate paddock security are obvious ones. Due to the practical limitations described above, annual fluctuations around a target utilisation rate will occur. The goal is therefore to maintain a long-term average utilisation rate that is sustainable for the land type in question. Annual deviations away from the target utilisation rate are probably not critical so long as high utilisation rates are not maintained when seasonal conditions continue to deteriorate.

5.2.5.2 The implementation of this practice

In the Barkly region, which has a fairly reliable wet season, forage budgets are best prepared at the end of the wet season (i.e. April/May). This timing coincides well with the first round musters on many properties in the north which is when paddock stock numbers can be adjusted. Producer feedback from regional workshops indicated that stocking rate adjustments of 20% to 30% per annum are typical of what is achieved 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 poor season.

A forage budget should be developed at the start of the dry season for the coming 12 months (i.e. until the following year round one muster). This should allow for adequate pasture residue at the start of the next wet season and for the possibility of a poor wet season. In northern Australia, the recommended end-of-dry season targets are ~1000 kg/ha residue and 40% cover in October in most years to minimise erosion and maximise infiltration when the first wet season rains occur (Post et al. 2006; McIvor et al. 1995; Scanlan et al. 1996). To maximise nutrient and water retention, at least 70% ground cover in October in most years is recommended (Post et al. 2006). Estimates of standing forage biomass at the end of the wet season, together with recommended sustainable utilisation rates, can be used to determine stock numbers for the coming 12 months.

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 does not 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, producers can learn how to do forage budgeting by attending one of DPIF's GLM courses.

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 (see Chilcott et al. 2005 for appropriate conversions). For example, removing weaners as early as possible in the dry season significantly reduces the feed demand of the breeder when feed quality and quantity is declining, which in turn helps her to retain body condition and increase her chances of future reproductive success. Such a management practice has the dual benefits of managing stocking rate (and thus land condition) as well as improving breeder performance. As mentioned previously, urea supplementation increases feed intake during the dry season by as much as 20% and must be taken into consideration when determining feed demand. The grazing pressure from feral and native herbivores also needs to be included when calculating the number of animals to be placed back into a paddock. DPIF can provide advice on calculating AEs from stock figures or producers can learn how to do this by attending a Barkly 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 feed budget can be calculated to determine how many cattle to remove in order to meet end-of-dry-season targets.

5.2.5.3 Considerations/caveats

Using forage budgeting in isolation to calculate potential increases in stocking rate is problematic given that it is usually based on what pasture has grown rather than on what will grow. Furthermore, there are many other factors that affect the practicality, desirability and risk 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 prescribed burning to manage woody plant populations where this is an issue (see Section 5.4).

5.2.6 Complementary management action 1: implement pasture spelling

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

5.2.6.1 Evidence supporting this management action

Whilst there has been considerable research on using pasture spelling to improve land condition, there have been few studies on the effects of pasture spelling on land in good (A/B) condition. The Ecograze project at Charters Towers showed that spelling paddocks for eight weeks in the early growing season each year, combined with 50% utilisation, gave similar pasture performance to 25% utilisation without pasture rest. Both these treatments maintained good land condition during the seasons experienced during the trial.

Palatable perennial grass species in northern Australia are particularly sensitive to defoliation early in the growing season (Ash et al. 1997). Pasture spelling during the early growing season (i.e. the first six to eight weeks of the wet season) allows preferred perennial grasses to replenish their root reserves and grow enough leaf to withstand grazing later in the year.

Cattle tend to return repeatedly to preferred patches. If pastures are not spelled, these preferred patches become chronically overgrazed, less palatable species increase and declines in land condition occur. By allowing patches to regrow under early wet season rest, they become more like the remainder of the pasture and animals are less likely to overgraze these patches, especially if spelling is combined with fire.

As an alternative to early wet season spelling, spelling for the entire wet season allows pasture species to replenish their root reserves and allows them to set seed. Producer experience in the Barkly suggests that spelling should commence before the start of the wet season and continue until seed set is complete. Producers at a recent workshop in the region felt that a six-month spelling period offers the best compromise between pasture recovery and animal management, but the duration could be modified depending on the individual wet season experienced. A practical method for achieving early wet season spelling or full wet season spelling is to remove cattle from the paddock during the second round muster.

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 the dry season are usually destocked during the wet season. Under this regime, the paddocks and laneways respond very well to rainfall and rest and are often in better land condition and have a larger amount of feed than nearby paddocks that are continuously grazed.

In terms of spelling frequency, a general conclusion from South African studies was that pastures in good condition should be spelled one year in four (and more often for pastures in poor condition). At a recent workshop, Barkly producers felt that spelling frequency will depend on the starting land condition. They felt that to recover poor condition land, spelling should initially be for a minimum of two wet seasons, and when the desired condition is attained, it should be spelled for one wet season every five years (White and Walsh 2010).

Figure 8 shows some GRASP modelling output that looked at the impact of spelling on land in A condition for the Barkly. At moderate to high stocking rates (>9 AE/km^2), good land condition could only be maintained long-term if spelling was included. For this simulation, a six-month wet season spell, once every four years, kept land in good condition. Without spelling, a considerable decline in land condition occurred during poor seasons, even at a moderate stocking rate.

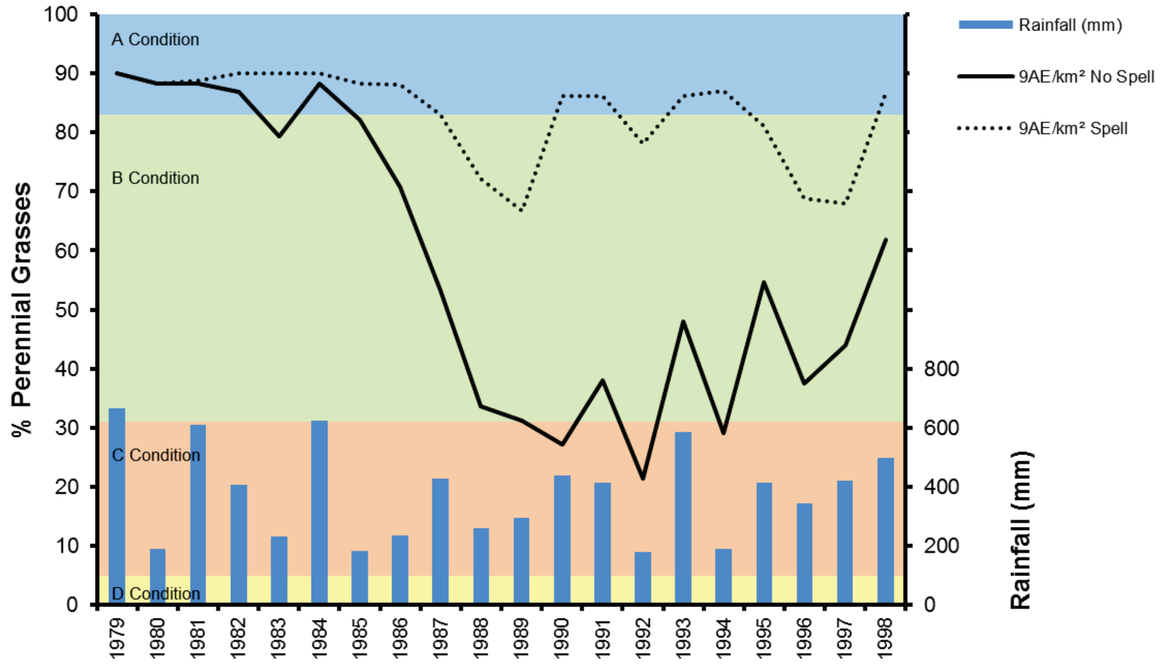


Figure 8. GRASP simulation of wet season spelling for a grey cracking clay on the central Barkly. Percentages of perennial grasses in the pasture are used as a proxy for land condition.

5.2.6.2 The implementation of this practice

In practice, to achieve either early or full wet season spelling, most producers will probably need to remove cattle from the paddock at the second round muster. In many cases, these paddocks might only be re-stocked during the next first round muster due to access issues.

Another common practice is to turn off bores and troughs in the wet season when cattle have access to surface waters in other parts of the paddock. This encourages cattle to graze away from the bores and troughs, gives the areas around the bores a spell and allows cattle to make use of under-utilised feed in outer areas of the paddock.

Where the aim is to grow more feed, spelling will need to occur during the growing season. If, however, the aim is to retain feed for later in the year, then spelling can be planned for any time. However, many producers are wary of "saving" large bodies of feed because they are a significant fire risk late in the dry season.

Where preferentially-grazed patches are obvious, rotational burning can help to "re-set" these patches and increase the even-ness of grazing after spelling (see Section 5.3.6).

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 should be done during good seasons (where there is more pasture available), animals should only 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 the wet season 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 failed wet seasons or droughts is the same as spelling. Destocking during periods of little to no pasture growth can protect the remnant grass tussocks and soils in the paddock but it 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 benefits.

5.2.7 Complementary management action 2: implement prescribed burning

Fire can 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.

5.2.7.1 Evidence supporting this management action

There is both experimental evidence (e.g. Andrew 1986) and a lot of practical experience to show that animals prefer burnt areas that are regrowing, to unburnt areas.

In a burning trial at Mt Sanford Station in the VRD, 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.

Although prescribed burning to modify grazing patterns is an uncommon practice on the Barkly, recent experimental evidence suggests that it could be a useful tool on black soil country (Materne in prep.). A trial on Alexandria Station showed that grazing activity was higher on areas that had been burnt due to the higher diet quality of the regrowth. This preference for previously-burnt patches was still evident two years after burning (Materne in prep.). This suggests that prescribed burning could be used to modify grazing patterns on black soil plains on the Barkly.

5.2.7.2 The implementation of this practice

In the Barkly region, prescribed burning in black soil paddocks is uncommon because producers prefer to use the grass for feed. Research in Mitchell grasslands in Qld has documented negative effects of fire on seed production and seedling establishment when follow-up rains do not occur. Although wet seasons are relatively reliable in the Barkly, an effective wet season is not guaranteed every year and the risk of a failed wet season deters many Barkly producers from using fire as a management tool. The trial at Alexandria confirmed that prescribed burning needs careful management because pasture cover and yields are significantly reduced for at least two years following the burn.

Experience in the Katherine region (which has a more reliable wet season) indicates that rotational burning (burning every four to five years) can “re-set” the pasture and improve the even-ness of grazing. In the Katherine region, 25% is considered to be the minimum area of the paddock to burn. 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 preferred parts of the paddock is also important. For example, in the Mt Sanford trial, burnt areas close to water were heavily overgrazed and became degraded.

Animals do not graze exclusively on the burnt areas, so there will be some grazing (and possibly continuing deterioration) on the non-burnt areas. A rotational burning strategy through time helps to overcome this issue. Dyer et al. (2003) noted several factors that should be taken into account when rotational burning:

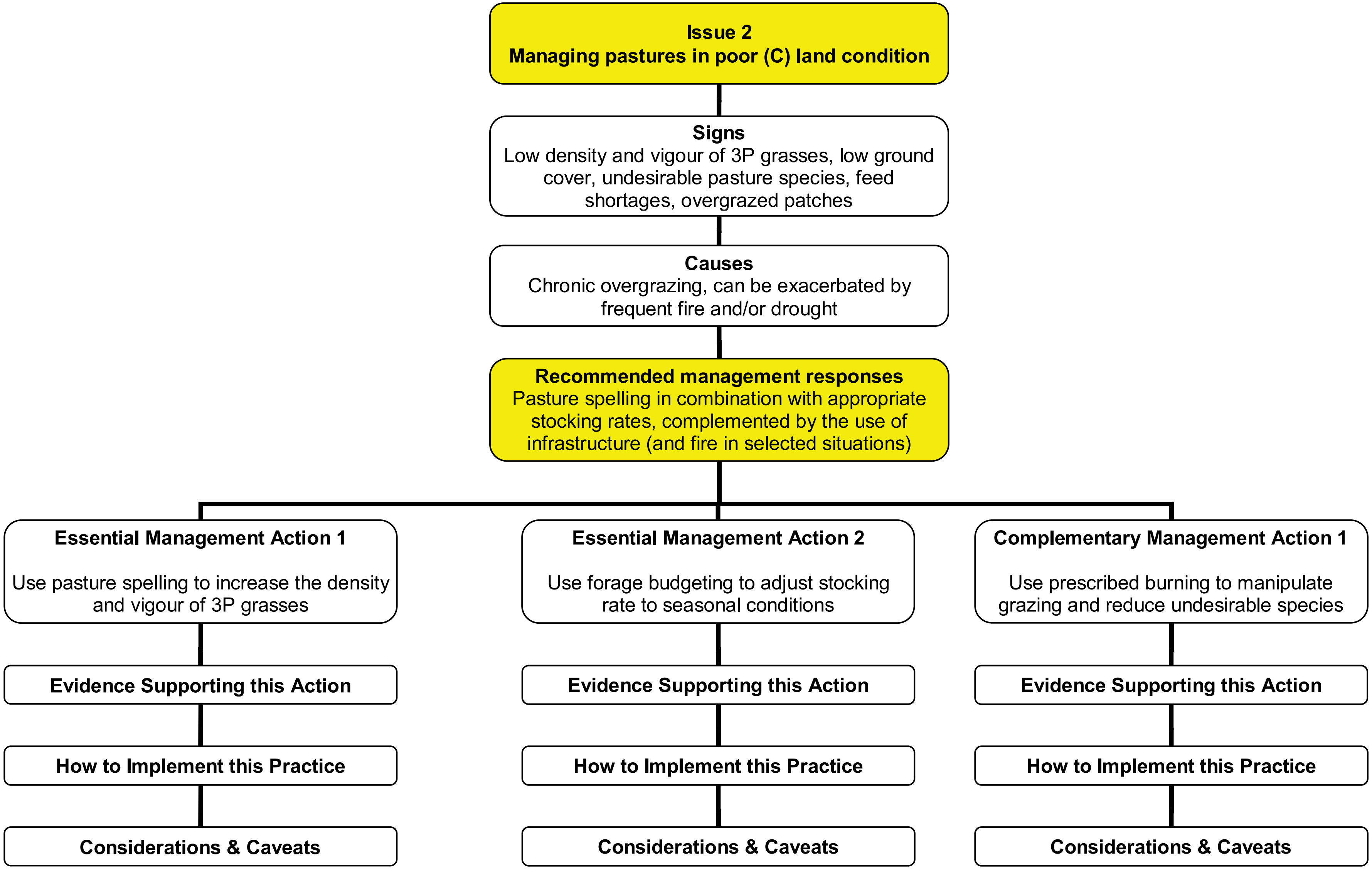
- Match the stocking rate to the new level of pasture available after burning.
- Do not re-burn areas for four to five years after burning.
- Be aware of the location of water points and preferred land types when burning.
- Do not burn areas that are already preferred by cattle as this can lead to excessive overgrazing 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

Obviously, stocking rates need to be adjusted to account for the lower pasture availability in the paddock if a large percentage is burnt. This can be achieved by calculating a forage budget.

Burning can increase or decrease the incidence of native woody species and exotic weeds. Advice can be sought from DPIF, Bushfires NT and DLRM’s Weeds Branch when planning a burning regime.

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 3P grasses, low ground cover, undesirable pasture species, feed shortages, overgrazed patches
Causes
Chronic overgrazing, can be exacerbated by frequent fire and/or drought
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 3P 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
How to Implement this Practice
Considerations & Caveats
Complementary Management Action 1
Use prescribed burning to manipulate grazing and reduce undesirable species
Evidence Supporting this Action
How to Implement this Practice
Considerations & Caveats

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 but there may be some patches in poorer condition. This section deals with pastures that have deteriorated and the paddock or property is now in poor condition. Note that land condition issues related to woody vegetation thickening are covered in Section 5.4.

NT Pastoral Land Board figures indicate that about 12% (n=77) of Tier 1 monitoring sites in the Barkly district and 29% (n=28) of sites in the Tennant Creek district were in poor land condition in 2007-08 (Pastoral Land Board 2010).

The dilemma for producers with land in C condition is how to manage animal numbers to minimise periods of feed shortage while using pasture spelling (and possibly 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 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 productive, palatable and perennial (3P) grasses (but they are small, widely spaced and have low vigour). Less palatable species are common, ground cover is generally poor with deteriorating soil surface condition, with some erosion and significant loss of moisture through runoff. In some cases there is a high proportion of undesirable species such as unpalatable perennial grasses and forbs. Although highly nutritious pasture may be available for short periods after rain, feed shortages can quickly develop.

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/frequent wildfire events. Frequent and severe defoliation can have deleterious effects on both individual plants by reducing their vigour and on soils and pastures by reducing land condition (lower cover and more bare ground, lower infiltration and more run-off, altered botanical composition, increased patchiness). Drought and intense wildfire can sometimes exacerbate the damage to already weakened pasture. High fire frequency can lead to the loss of fire-sensitive species and prevent preferred pasture species from replenishing their root and seed reserves.

The 3P grasses are typically selectively grazed within the pasture leading to them being weakened, which results in a reduction in their size and vigour and then their death. Seed production of 3P grasses may be seriously limited or prevented altogether and recruitment of new 3P grass seedlings will be minimal.

With the decline of 3P grasses, other plants which have strategies to survive the grazing pressure tend to increase. These may be quick-growing and prolific seeding species, or species with unpalatable traits that livestock avoid (e.g. wiregrasses, rattlepods). 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 3P grasses to increase in the pasture and minimise the loss of soil and moisture in runoff. 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, exposing bare soil 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.

5.3.4 Essential management action 1: use pasture spelling to increase the density and vigour of 3P grasses

A general recommendation for improving pasture condition is to have a planned but flexible regime to spell target paddocks for the whole growing season commencing from the first rain event sufficient to initiate new growth (e.g. 50 mm in three days). 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 growing season, duration of discrete 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

Wet season spelling, and particularly spelling during the early growing season, has been widely recommended across many regions, though often with little local data on which to base cost-effective management strategies. The existing experimental data from a limited number of regions indicates that spelling during the wet season, and particularly during the early growing season when grasses are most susceptible to heavy defoliation, is important for managing 3P grasses (Ash and McIvor 1998; Hunt et al. 2010).

At the individual 3P grass scale, the grass needs time to grow a leaf canopy (often from low root reserves), re-build root reserves for the following dry season and future wet season leaf flush, and produce seed. Seedlings require time to grow and develop robust root reserves to survive the following dry season. Consequently, longer rest periods may have advantages over shorter periods in terms of accumulated benefit.

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) and growing conditions experienced during the rest period (pasture maintenance and recovery are boosted by good seasonal conditions). Establishment of seedlings from the seed set during an earlier rest period may be enhanced by a subsequent rest period.

At a local workshop, Barkly producers agreed that spelling frequency will depend on the starting land condition. They felt that to recover poor condition land, spelling should initially be for a minimum of two good wet seasons, and when the desired condition is attained, it should be spelled for one wet season every five years. An example was given of areas that were dominated by weedy species (e.g. galvanised burr) for the first couple of wet seasons they were spelled but then returned to Mitchell grass/Flinders grass dominance with further spelling. This experience, together with the results of modelling from the region, highlight that hard evidence is needed in order to convince some producers to “hang in there” with spelling if immediate results are not forthcoming.

Exploratory bio-economic modelling for the Barkly shows that the best and most practical option for improving land condition from C to B is to use safe stocking rates and wet season spells for six months over the wet season, every four years. In model simulations, this spelling regime led to improved land condition (Figure 9) and higher cattle live-weight gains (Table 3). The modelling also demonstrated that low stocking rates (without spelling) can also lead to improved land condition, but with lower live-weight gains per hectare compared with spelling in combination with safe stocking rates (Figure 9, Table 3).

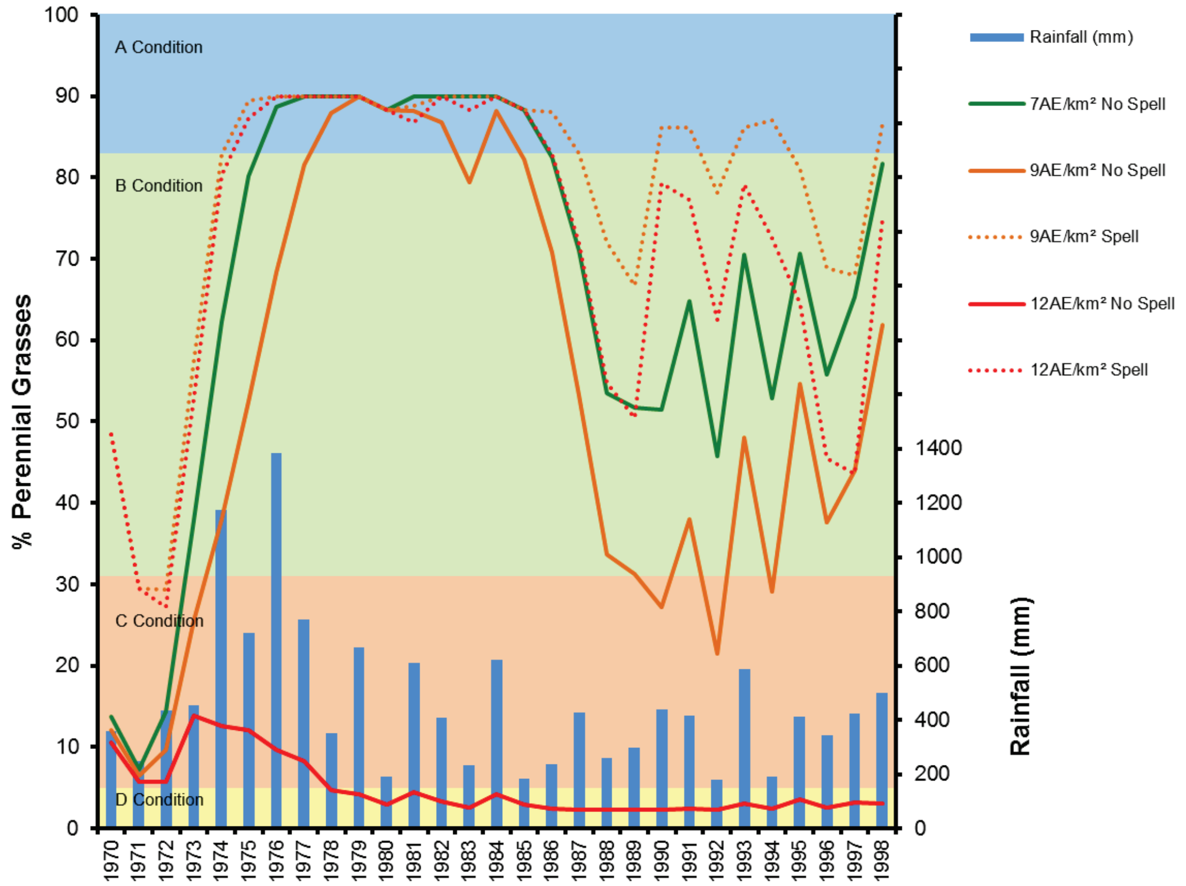


Figure 9. GRASP simulation of wet season spelling and stocking rate management for a grey cracking clay on the central Barkly. Percentages of perennial grasses in the pasture are used as a proxy for land condition. Spelling at higher (but still safe) stocking rates produced the fastest improvements in land condition and achieved the best live-weight gains per hectare. At high stocking rates with no spelling, land condition never improved. Note that the starting year can have a large impact on the results – in this case the early 1970s were good seasons which helped to improve land condition very quickly in some scenarios.

Table 3. GRASP simulation results for average live-weight gain per hectare for the above stocking rate and spelling scenarios (1970-98) for a grey cracking clay on the central Barkly

Stocking rate and spelling scenarios	Average live-weight gain (kg/ha)
7 AE/km² (no spelling)	5
9 AE/km² (no spelling)	3
9 AE/km² + six month wet season spell every four years	7
12 AE/ km² (no spelling)	-8
12 AE/km² + six month wet season spell every four years	5

Increasing the number of rest periods can be expected to give a greater pasture response but represents a trade-off as grazing is foregone during the rest period. There are no experiments in northern Australia dealing explicitly with comparisons of the frequency of rest periods but a number of trials provide useful information indicating that as land condition declines, pasture rests need to be more frequent if land condition is to be improved (McIvor et al. 2010). Minimal gains will be made with spelling if stocking rates are not matched to feed supply following the rest period and ongoing overgrazing occurs.

There is some limited evidence that rest during the dry season may also be useful for retaining ground cover and improving rainfall infiltration for the following growing season (McIvor et al. 2010).

5.3.4.2 The implementation of this practice

Most response to spelling seems to occur in the early part of the growing season, so the duration of the rest period for poor condition pastures should be a minimum of eight weeks from the start of effective growth. However, a full wet season spell may be more practical to manage and perhaps more cost-effective in some situations. Pasture responses to spelling are much lower in below-average rainfall years compared with average or good years; so cost-effectiveness is likely to be higher in better rainfall years.

A common question is how to prioritise paddocks for spelling. Bio-economic modelling for the Barkly found that the results of spelling were very variable depending on which paddock was spelled and the seasonal conditions experienced during the spelling period. Where there are several paddocks in C condition that are to be spelled in some type of rotation (and the cattle are kept on property rather than sold or agisted), the paddock that is spelled last may suffer long-term declines in condition as a consequence of the extended duration of increased stocking rate it has suffered if sequences of poor seasons are experienced (Figure 10).

The modelling indicates there is potentially a large effect of the year during which the spelling occurs. In a good growth year, the higher stocking rates in the 'loaded-up' paddocks may still be within safe utilisation rates, so no damage occurs and land condition will stay the same or slightly improve. In a poorer growth year, a spelled paddock may improve slightly but the 'loaded-up' paddocks could well be damaged and may take even longer to recover. This suggests that the paddock with the most area of C condition should be spelled first to minimise further damage.

Producers in the Barkly who are interested in spelling are adamant that spelling regimes need to be applied flexibly rather than rigidly, so that seasonal conditions can be taken into account. Spelling is likely to achieve the best result in good seasons, so the cattle from the paddock to be spelled might well be retained and put into other paddocks because the feed supply is able to support them. In average or poorer seasons, the other paddocks may not be able to support these additional cattle and they may need to be sold or agisted to achieve the spell. 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 land condition and forage supply (rather than just spreading them evenly across the other paddocks).

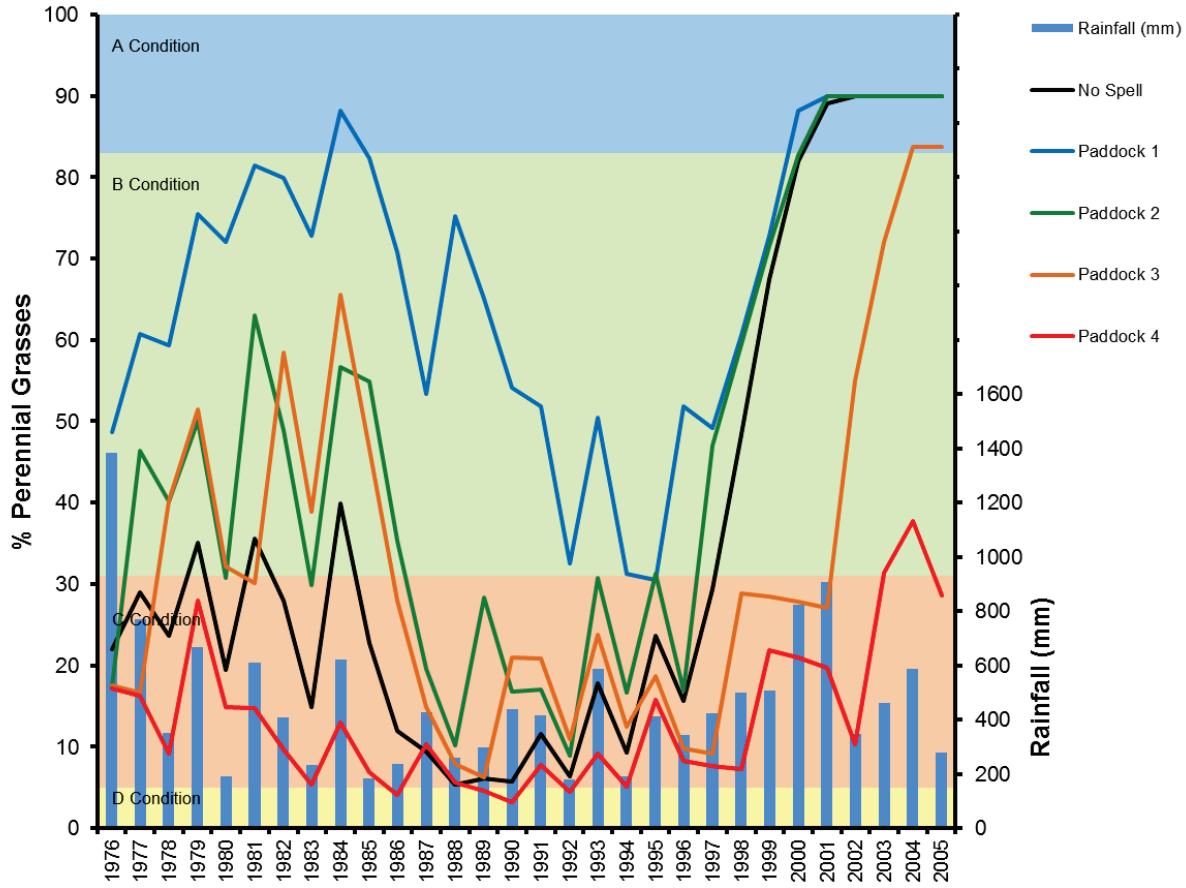


Figure 10. GRASP simulation of a six month spell every four years achieved via a four paddock rotation system, where the cattle from the paddock being spelled are spread evenly amongst the other three paddocks. A non-spelled paddock is included for comparison. Percentages of perennial grasses in the pasture are used as a proxy for land condition. The land condition performance of individual paddocks varied depending on where in the order they were spelled, and the seasonal conditions they experienced. For example, Paddocks 3 and 4 performed worse than the non-spelled paddock because they received additional cattle from the other spelled paddocks early in the rotation. As a consequence, Paddock 4 was not able to achieve any significant recovery in land condition.

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 only a supplementary tool for improving land condition and is less important than spelling and stocking rate management, particularly on the Barkly where prescribed burning is not common practice. Fire can be used to attract cattle away from areas to be spelled because animals prefer to graze recently-burnt areas over 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. Some undesirable pasture species can also be manipulated using prescribed burning.

5.3.6.1 Evidence supporting this management action

Fire can be used to spell parts of paddocks because animals prefer to graze recently-burnt areas over non-burnt areas. This will give some spelling to the non-burnt areas and has been effective under experimental conditions but its effectiveness under commercial conditions is unknown. 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 a small area is burnt, the concentration of grazing may also do more harm than the benefit derived on the non-burnt area.

Fire can be used to remove old patches of dry mature herbage so that all young material is equally accessible. 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. Local knowledge will be required to determine the likely response of individual species in a specific region. Undesirable species can be split into three categories based on their response to management actions:

Managing species that are sensitive to fire

Some undesirable grass species are sensitive to fire. Fire can be used to manipulate species composition by killing plants, influencing recruitment or altering grazing preferences. Local knowledge should be sought to determine the expected impact of individual fires or particular fire regimes on the specific targeted unpalatable grass species. Some unpalatable grass species may be encouraged by fire. The fire regime may also encourage other desirable species.

Managing species that are sensitive to grazing management and competition from other pasture species

Some unpalatable species cannot be managed with fire but may be sensitive to grazing management through competition from 3P grasses.

Overgrazing for long periods and ongoing selective grazing reduce the vigour of 3P grasses and may allow other grasses and forbs to establish and dominate. In this situation, matching stocking rates to the 3P grass forage and spelling may be useful to allow the 3P grasses to recover and compete successfully with undesirable species (see Section 5.2 on matching stocking rates to carrying capacity and pasture spelling).

Managing species that are insensitive to grazing management or fire

Some introduced and native undesirable species are insensitive to grazing management and fire, such as *Eulalia aurea, Flemingia pauciflora*, *Tephrosia* species and *Trichodesma zeylanicum*.

In this situation, management actions are limited, especially in rangeland situations. The best management action in extensive, lower productivity country may be to match stocking rates to palatable feed supply so the desirable species are not further overgrazed and the undesirable species is not further encouraged.

5.3.6.2 *The implementation of this practice*

For Barkly producers interested in the use of fire for influencing grazing management and pasture composition, the implementation of a fire regime will require planning to ensure adequate fuel is available. This may mean adjusting stocking rates or spelling to preserve fuel, followed by conservative stocking 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 at one time.

Producers need 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). The intensity of fire for changing the composition of the herbaceous layer appears to be less important than for managing woody species. 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).

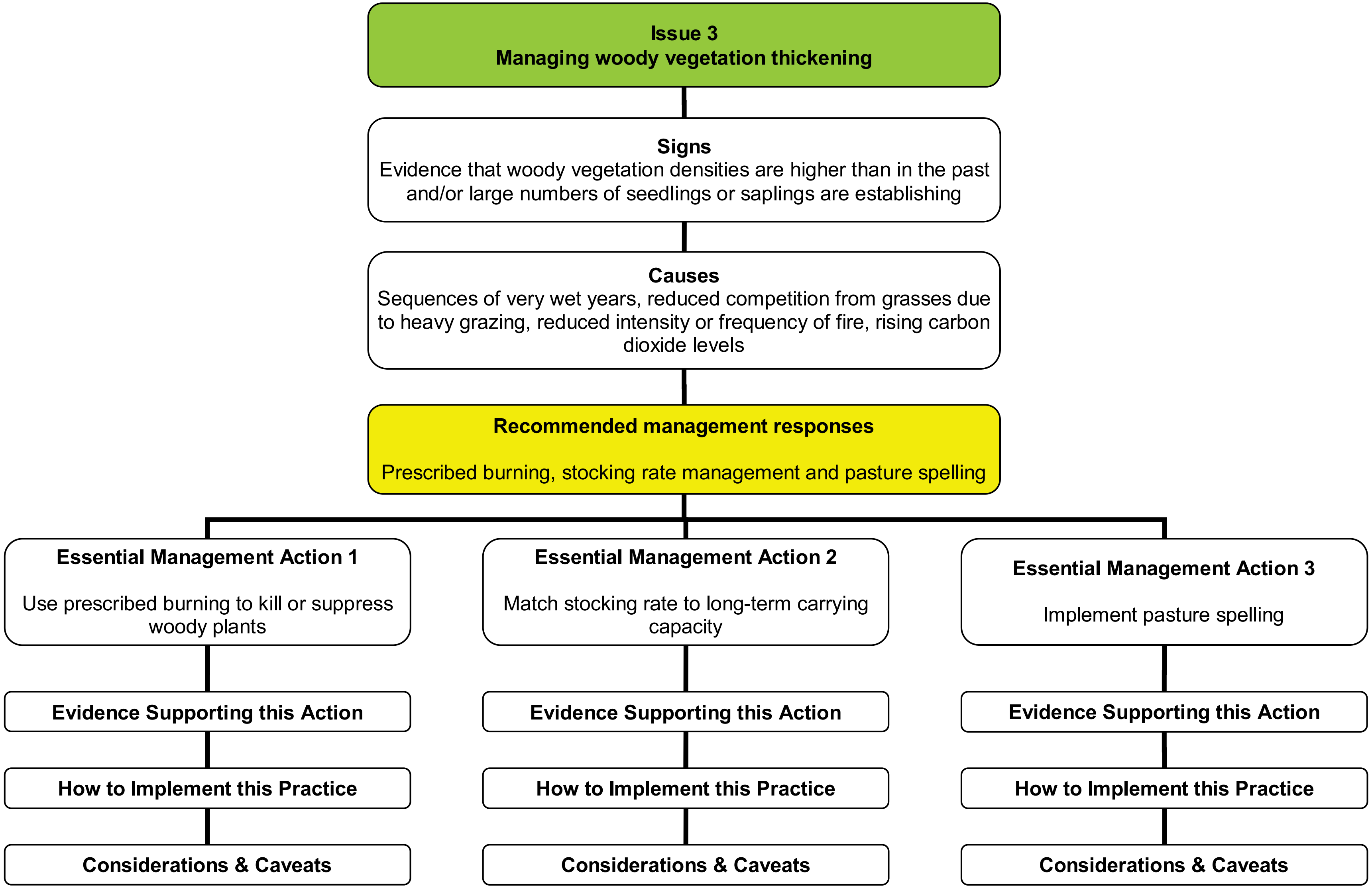
Post-fire spelling and stocking rates will be critical for maximising any benefits of using fire to manage herbaceous species. Where there are few desirable plants, there may be little positive response to prescribed burning in the short to the medium term.

Using the fuel accumulated in above-average rainfall seasons will minimise the opportunity cost of spelling prior to burning. Look for opportunities to address two or more ‘purposes’ with the same fire regime (e.g. spell an area, manage an unpalatable grass, increase the even-ness of use and/or improve pasture quality). The risk of a poor season should also be considered and appropriate management 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 an already weakened pasture, reduce cover to unacceptable 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 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 ideal that palatable, perennial grasses are allowed to set seed in the post-fire period and this may require destocking or, at least, very low stocking densities. If pre- or post-fire destocking is necessary, forage must be available for livestock on other parts of the property or they will have to be agisted or sold.

Fire can promote germination of some woody species, notably acacias on red soils. 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 the plants set seed can reduce the build-up of seed-banks of such species as acacias.



Issue 3
Managing woody vegetation thickening
Signs
Evidence that woody vegetation densities are higher than in the past and/or large numbers of seedlings or saplings are 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
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

5.4 ISSUE 3: MANAGING WOODY VEGETATION THICKENING

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

Woody species vary in their growth form, mode of reproduction, 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 northern Australian vegetation.

Although the woody components of northern Australian pastoral lands are 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 of exotic trees, shrubs and woody vines. Different species are involved in different locations and often there are multiple species involved.

Woody plants can be problematic for pastoral production reliant on natural or semi-natural vegetation. The following are the major issues, though their 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).
- Woody vegetation may provide habitat for pest animals such as feral pigs.

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).

Many pastoral areas of northern Australian include some woody species that are not native. Examples of concern in the Barkly include parkinsonia (*Parkinsonia aculeata*), prickly acacia (*Acacia nilotica*), mesquite (*Prosopis* species) and rubber bush (*Calotropis procera*). In some parts of the Barkly, various native woody species are a concern to pastoralists. These species include conkerberry (*Carissa lanceolata*), turpentine (*Acacia lysophloia*), lancewood (*Acacia shirleyi*), bullwaddy (*Macropteranthes keckwickii*) and *Vachellia farnesiana* (needlebush).

5.4.1 Signs

In general, the biomasses of woody and herbaceous components of the vegetation are inversely related to one another: all else being equal, higher woody plant biomass is associated with lower herbaceous biomass. The size, number and distribution of woody plants can all be useful indicators of the impact that woody plants are having on the herbaceous layer. A low density of large scattered trees and shrubs is likely to have little deleterious effect on a pastoral production system and may, in fact, be beneficial.

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. Darrell Lewis' book "Slower than the Eye Can See" is a good example of using repeat photography to document woody vegetation change in the VRD (Lewis 2002). 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*), prickly acacia (*Acacia nilotica*), mesquite (*Prosopis* spp.) and parkinsonia (*Parkinsonia aculeata*), which are known invasives, indicates a threat of increasing exotic woody weeds.

5.4.2 Causes

Many factors drive tree and shrub populations. Some of the important ones are indicated in Figure 11 which portrays the dynamic balance between woody and herbaceous (mainly grasses) components of the vegetation. The main drivers of the dynamic are rainfall as a promoter of germination and growth, drought or poor wet seasons as a cause of mortality, competition between grasses and woody species (for water, nutrients and/or light), grazing and browsing differentially affecting biomass and possibly survival, and fire as a remover of herbaceous biomass and a cause of top-kill and mortality of woody species. Some of these factors can be managed; some cannot. Among the factors driving observed or quantified increases in populations of woody plants include sequences of very wet years, reduced competition from grasses due to heavy grazing, reduced frequency and/or intensity of fire because of lack of fuel or active fire suppression or, as suggested in some literature, rising CO_2 levels. One important relationship is between plant size and susceptibility to fire. For many species, small plants are more susceptible to fire than large plants. This means that increasing "woodiness" associated with a lack of fire can create a positive feedback in which effective fire becomes less likely. This feedback loop is exacerbated by the negative effect of increasing woodiness on fuel loads.

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?

5.4.3 Management responses: prescribed burning and grazing management

Fire and grazing/browsing are the key manageable factors that influence the woody components of northern Australian vegetation. Critically, these two factors interact with one another (Figure 11) because herbivores and fire compete for herbaceous material. Prescribed burning thus constitutes a management response to increasing woodiness of northern Australian vegetation. In the Barkly region, prescribed burning is likely to be most useful for managing native woody vegetation on red soils and some invasive species on black soils.

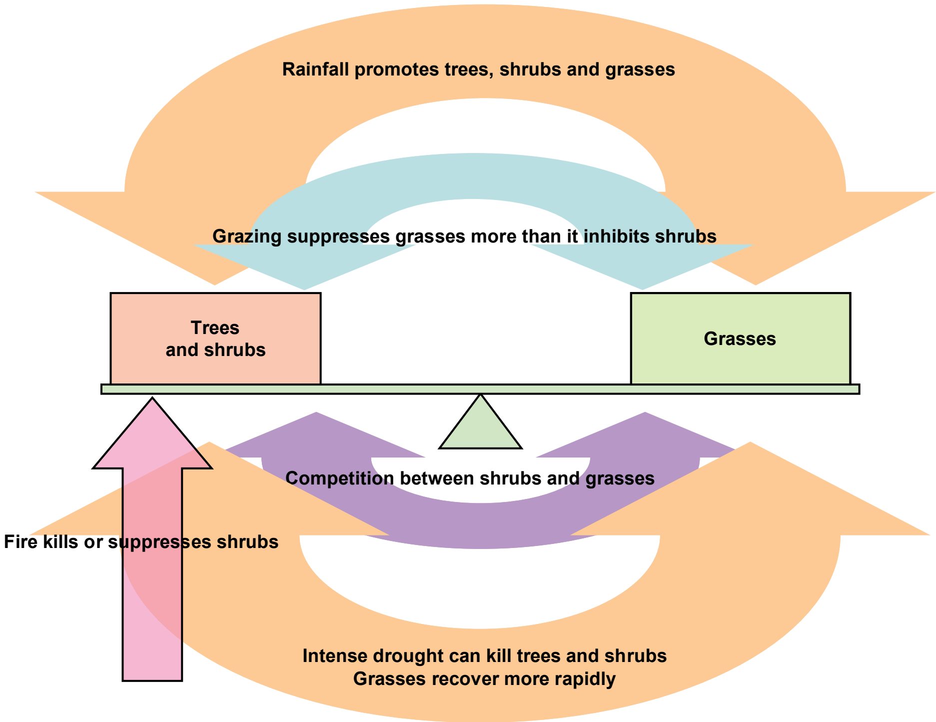


Figure 11. Factors that affect tree and shrub populations

5.4.4 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 open 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 (i.e. small) shrubs.

5.4.4.1 Evidence supporting this management action

Much of the fire research that has been conducted in northern Australia has focused on the ecology and management of the woody plant strata of the vegetation. This work has included research on native plant communities in the Top End and the VRD of the NT and the northern Gulf savannas and Cape York Peninsula woodlands in Qld, as well as on invasive woody species in the Burdekin woodlands of north-east Qld. Research is lacking for many regions and vegetation communities, including the Barkly.

Evidence from the Katherine region confirms that woody species compete with grasses for both nutrients (such as nitrogen) and moisture during the growing season. Woody thickening thus has a negative impact on pasture yield and/or quality (Dyer et al. 2003). In higher rainfall areas (e.g. the northern VRD), pasture growth is constrained more by nutrients than by moisture in most years due to the rapid dilution of soil nitrogen. In lower rainfall areas (e.g. the southern VRD), soil moisture is a bigger constraint to grass growth than nutrient dilution (Dyer et al. 2003). This means that in higher rainfall areas, increased woody vegetation is likely to reduce pasture quality (due to nitrogen dilution) before it impacts on pasture yield. The opposite is true in drier areas and is probably the case in the Barkly.

When the costs and benefits of various burning regimes in the VRD were compared using modelling, the results indicated that late dry season burning gave the best economic outcome over the long term and that early dry season burning was more economically beneficial than not burning at all (Dyer et al. 2003). The costs associated with burning (e.g. mustering, de-stocking, wildfire control and implementing a prescribed burn) were highest for wildfire and late dry season burning and lowest for biennial early dry season burning. The long-term suppression of fires led to the highest mustering costs due to the increase in tree cover making it difficult to locate and move cattle. Even though the costs associated with late dry season burning were high, the improvements in average live-weight gain, branding rate and mortality rates resulted in higher livestock turn-off and revenue for this scenario in the VRD (Dyer et al. 2003).

Unpublished burning trial results from the Barkly region (Materne in prep.) show that prescribed burning increases the mortality and top kill of several woody species, such as corkwood wattle (*Acacia sutherlandii)* and gundabluie (*A. victoriae*).

5.4.4.2 The implementation of this practice

Little published data exists for implementing prescribed burning in the Barkly region. The VRD research showed that woody plant mortality rates are determined mainly by vegetation height, with smaller plants being more susceptible to burning (Dyer et al. 2003). However, regardless of height, outright mortality rates for most woody species are relatively low (<5%). Fires are thus best used to suppress the cover and size of woody plants (through canopy “top kill”) and by preventing further increases in plant density. The taller the vegetation, the higher are the fuel loads and high wind speeds are needed to achieve a successful top kill. Thus, there is a greater likelihood of having the minimum required combination of fuel loads and wind speeds to achieve a successful fire if woody vegetation is burned when it is small (e.g. <2 m). The most effective conditions for reducing woody cover are fuel loads above 2500 kg/ha and cover >60% during high temperature, low humidity and constant breeze conditions late in the dry season (Dyer et al. 2003).Unpublished results from the Barkly support these principles.

In most cases, perennial grass pastures in good land condition are resilient and benefit from periodic dry season burning (Dyer et al. 2003). On black-soil ribbon-grass/bluegrass pastures in the VRD, burning every four to six years is recommended to control woody vegetation cover and remove the accumulation of rank pasture. In arid short grass pastures in the VRD, where there is a higher risk of negative impacts on land condition after burning, less frequent burns (e.g. every five to six years) during periods of above-average rainfall and under low to moderate grazing pressure are recommended. This provides a good balance between maintaining pasture composition and woody vegetation management (Dyer et al. 2003). High burning frequencies (e.g. fires three years in five) in arid short grass pastures in the VRD favoured annual grasses over perennials and left soils exposed to erosion and are not recommended. There is some evidence to suggest that less frequent fires (every five to 10 years) of higher intensity may achieve a similar result to more frequent fires of lower intensity. A fire regime such as this is also less disruptive to the grazing enterprise. The minimum paddock area to burn is considered to be 25% in large paddocks (i.e. paddocks more than 40 km^2). Any less than that and animals will concentrate on small burnt areas and may negatively impact on preferred pasture species through overgrazing. Although similar dynamics would be expected in the Barkly region, there is a higher risk of a failed wet season following burning. Burning productive annual pastures such as those dominated by Flinders grass (*Iseilema* spp.) and bottlewashers (*Enneapogon* spp.) is also not recommended (Chris Materne pers. comm.).

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

GRASP modelling for the Barkly illustrates how stocking rates can impact on potential fuel loads (Figures 12 and 13). The modelling indicates that over the past 100 years, there were very few years where fuel loads would have been adequate (>2000 kg/ha) to achieve a hot (i.e. late dry season) fire on gravelly red earth soils, particularly at higher stocking rates. There were more opportunities for hot fires on cracking clay soils; but again, the number of years of adequate fuel loads decreased with increasing stocking rate. At the heaviest stocking rates, there were no opportunities for a hot fire.

The modelling confirms that there will be more opportunities to reach the minimum fuel loads required to carry a cool fire (800 kg/ha); but once again, high stocking rates reduce the number of years when fuel loads will be adequate (Figures 12 and 13). For gravelly red earths, stocking rates above 3 AE/km² greatly reduce the number of years that fuel loads are adequate to conduct a cool burn and on grey cracking clays, stocking rates above 9 AE/km² reduce the opportunities to ≤30% of years. These simulations suggest that lower stocking rates and/or pasture spelling will be required to maximise opportunities to accumulate adequate fuel loads to conduct prescribed burns.

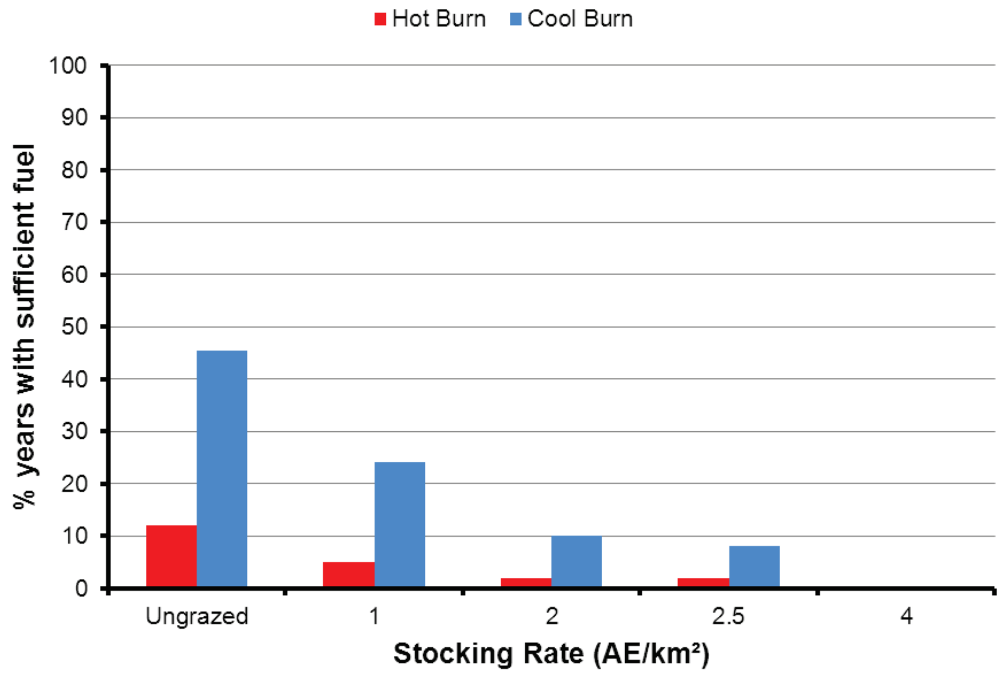


Figure 12. GRASP simulation showing the interaction between stocking rate and fuel load for a gravelly red earth (Wonorah land system) on the Barkly. The figure indicates the number of years that fuel loads would have been adequate to achieve a cool fire (>800 kg/ha) or a hot fire (>2000 kg/ha) in the last 100 years.

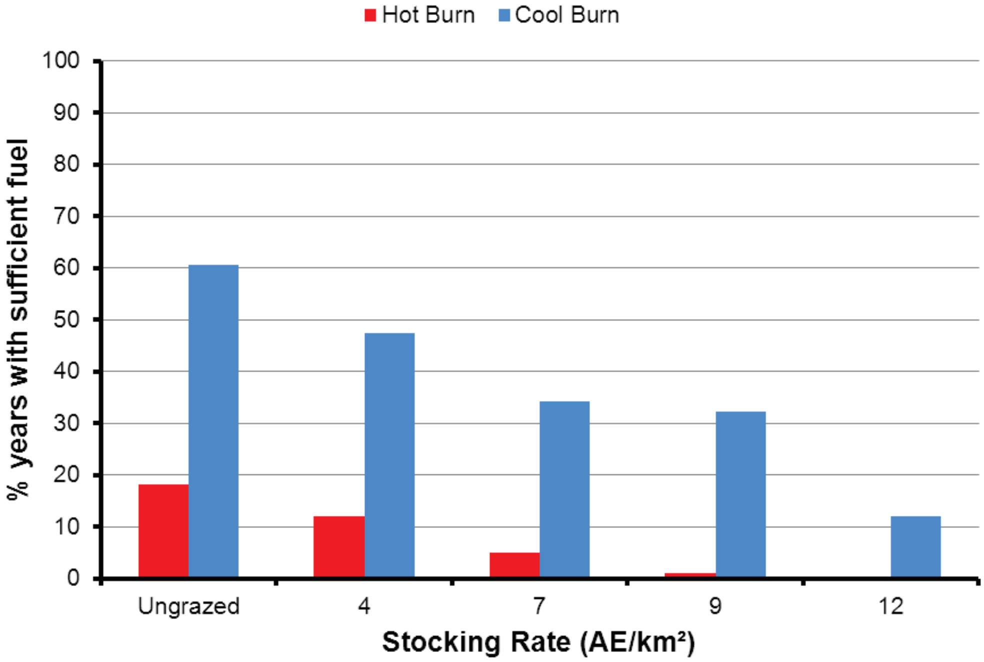


Figure 13. GRASP simulation showing the interaction between stocking rate and fuel load for a grey cracking clay soil (Barkly land system) on the Barkly. The figure indicates the number of years that fuel loads would have been adequate to achieve a cool fire (>800 kg/ha) or a hot fire (>2000 kg/ha) in the last 100 years.

5.4.4.3 Considerations/caveats

There are some important considerations when contemplating the use of fire to manage woody plant populations. The first is that prescribed burning comes at a cost. Costs will be associated with any spelling of pastures that is required in order to build up fuel loads so that an effective fire can be achieved. Burning when fuel loads are inadequate to achieve the purpose of the fire is obviously counter-productive. Likewise, it is important that pastures are not grazed too soon after the fire. Grazing in the immediate post-fire period hinders the recovery of desirable pasture species. In particular, it is important that palatable, perennial grasses are allowed to set seed in the post-fire period and this may require destocking or, at least, very low stocking densities. If pre- or post-fire destocking is necessary, forage must be available for livestock on other parts of the property or they will have to be agisted or sold.

Modelling from the VRD shows that the economic benefits of prescribed burning may take more than 20 years to become apparent (Dyer et al. 2003). 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.

Fire can promote the germination of some woody species, notably acacia species (e.g. turpentine). It is important to monitor the area in the post-fire period in order to be able to respond appropriately to large-scale germination events. If large recruitment events are triggered by a fire, a second fire may be useful. Conducting a second prescribed fire before recruits set seed can reduce the build-up of seed-banks of such species as acacias.

5.4.5 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 perennials. As outlined above, it also reduces the opportunity for conducting prescribed fires. Matching stocking rate to long-term carrying capacity increases the window of opportunity for incorporating effective fire into the management system.

5.4.5.1 Evidence supporting this management action

Fire and grazing basically compete for grass biomass. The general relationship between stocking rate and herbaceous biomass is well established though the specifics vary between land types and climatic zones. In the Barkly, 2000 to 2500 kg/ha is considered to be the minimum fuel load for an effective fire for woody plant management; this threshold will be reached more frequently in higher rainfall years and/or where stocking rates are lower. Grazing by feral and native herbivores influences herbage availability in the same ways as domestic stock.

5.4.5.2 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 contiguous areas requiring similar fire regimes are fenced together. On red soils, utilisation rates in the order of 10%, in combination with good pasture growth years, will probably be required to achieve sufficient end-of-dry season fuel loads to achieve a late burn for managing woody vegetation.

The intensity of a fire will be affected by the amount of fuel available but also by weather conditions and the state of the fuel at the time of burning. Low fuel moisture (for example <35%), high atmospheric temperatures, low relative humidity and high wind speeds will lead to higher intensity fires. Lower intensity, or just slower moving fires, with longer residence times may actually lead to higher mortality rates of some trees and shrubs.

An unpublished study on Mitchell grass on the Barkly found that late dry season fires had fuel loads between 1800 and 2700 kg/ha and moisture content of between 12% and 26% (Materne in prep.). These fires tended to burn cooler and slower than fires earlier in the year due to breaks in the continuity of the fuel load caused by grazing and trampling (Chris Materne pers. comm.). Late dry season fires tended to burn well only when the fuel was well-cured (Chris Materne pers. comm.). However, under these conditions, there was insufficient moisture to initiate growth, which left the soil vulnerable to erosion. Early dry season fuel loads of 2600 to 3500 kg/ha with moisture contents of 18% to 27% resulted in slow (around 3 km/hr) fires with variable flame heights of between 1.5 and 5 m). Scientific and anecdotal evidence from the Barkly shows that the abundance of Flinders grasses (*Iseilema* spp.) determines whether a fire will carry across black soil country (Chris Materne in prep.). However, burning monocultures of productive annuals (such as Flinders grasses) is not recommended due to negative impacts on seed production and cover.

5.4.5.3 Considerations/caveats

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

5.4.6 Essential management action 3: implement pasture spelling

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

5.4.6.1 Evidence supporting this management action

See Section 5.3.4.

5.4.6.2 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, a longer period of spelling is required in order for a target threshold of herbaceous biomass to be reached. Thus there will be great temporal and spatial variation in what constitutes appropriate pre-fire and post-fire rest periods. In highly favourable seasons, it will be possible to conduct an effective prescribed fire without a pre-fire rest period as herbaceous production will exceed off-take by livestock.

5.4.6.3 Considerations/caveats

See Sections 5.2.6.3.

Issue 4
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

Essential Management Action 2

Reduce paddock size

Evidence Supporting this Action

How to Implement this Practice

Considerations & Caveats

5.5 ISSUE 4: BRINGING UNDER-UTILISED PASTURES INTO PRODUCTION

Considerable areas of ungrazed palatable forage often occur in large paddocks. In 2001, it was estimated that 32% of the Barkly region was beyond 5 km from water (Fisher 2001) and whilst this figure is likely to have reduced, anecdotal evidence suggests that large areas are still beyond the reach of cattle. The unused pasture represents livestock production that is forgone by the pastoral industry, whilst areas near water often become degraded through overgrazing. Management options that create the opportunity for cattle to use pastures distant from water have the potential to increase returns to the livestock enterprise by allowing more cattle to be carried (where paddocks are currently stocked below the carrying capacity) 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 the water point and fencing infrastructure on a property to improve grazing distribution is the primary management option to address this issue, although fire may sometimes have a role (to remove accumulations of old forage and improve grazing distribution) and spelling may aid the recovery of previously overgrazed areas.

5.5.1 Signs

In large paddocks (i.e. >100 km² in the Barkly), significant areas of the paddock distant from water receive little or no grazing and accumulate masses of ungrazed herbage. 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.

5.5.2 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 northern Australia, 80% to 90% of grazing activity occurs within 5 km of water, with 55% to 60% of this occurring within 3 km of water (Fisher 2001). This places a limit on the distance from water that animals can graze and can result in large amounts of pasture beyond the usual foraging distance from water being left ungrazed. 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, reproduction and the maintenance of body condition (Streeter 2006). 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 these problems.

If stocking rates for a paddock are based on paddock size but there are too few water points to fully water 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 the best return on investment?

b. Can water points be used to improve grazing distribution without the need for additional fencing?

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

5.5.3 Management responses: develop water and paddock infrastructure

The most important management response involves improving access to pasture 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 by reducing the number of head per water point. In turn, this can lead to increases in individual animal production due to the increased quality and quantity of forage available per animal.

5.5.4 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 should not be separated by more than about 5 km to 6 km. A good rule of thumb is to allow one water point per 20 to 25 km^2 of land area.

5.5.4.1 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 (McIvor et al. 2010).

Although a number of studies have reported the maximum distance cattle will walk from water to forage in northern Australia (e.g. up to 11 km on the Barkly Tableland and usually no further than 5 to 8 km in Central Australia), most grazing by cattle occurs much closer to 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 80% to 90% of cattle activity occurred within 5 km of water, with about 55% to 60% of this occurring within 3 km of water (Fisher 2001). Although some cattle activity occurred further from water, this was low, particularly at the extreme distances. Thus, grazing pressure usually declines markedly beyond about 3 km from water, although cattle will use areas farther out if water points are sparse.

Given that the Barkly region is not fully developed, there is some potential to sustainably increase stock numbers with additional infrastructure on those properties that have low utilisation rates and productive soil types that are not fully watered. For those running at, or above their carrying capacity, further infrastructure development should be seen as an opportunity to spread current grazing pressure 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.

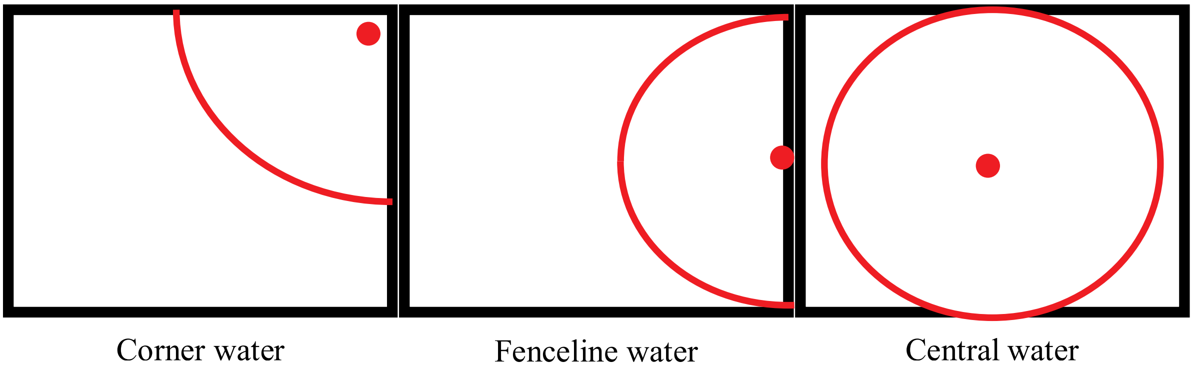
In the Pigeon Hole project in the VRD, where additional water points were established in a large paddock, approximately 90% of cattle activity (assessed using GPS collars) occurred within 3 km of water. After infrastructure development, a large proportion of this paddock fell within 3 km of water (the average distance to water in this paddock was 2.1 km). As a result, there were fewer areas where ungrazed forage accumulated. Establishing new water points in large paddocks at Pigeon Hole allowed more cattle to be carried because more of the country was accessible for grazing. Thus, a general recommendation to improve the effective use of available pasture and minimise the size of areas of ungrazed pasture in the more extensive grazing regions is for the majority of a paddock to be within 3 km of water and the distance between water points not to exceed approximately 6 km (Hunt et al. 2010). Producers at recent workshops in the Barkly region felt that it is not always economically viable to develop water points at this recommended maximum distance of 6 km.

Unwatered black soil country is the primary target for development on many Barkly properties. One producer at the workshop gave an example of how he had been able to increase watered area at a cost of between $90 and $400 per breeder unit, which is significantly cheaper than buying more land. This development is based on water points with a 5 km grazing radius and he felt it was necessary to monitor the impact of this level of development on land condition over several years before deciding whether to reduce the distance between water points any further. On another property, poly pipe has been used to create water points 4 km apart based on the observation that the common grazing radius on the property is about 2.5 km from water. This development cost came to about $225 per breeder and again the country is being monitored to determine the success of this strategy in order to inform further development. This is consistent with the approach being taken by at least one station on the Barkly (White and Walsh 2010). However, other producers are yet to be convinced that such close development is economically viable in extensive areas such as the Barkly. Some producers argue that the need to balance additional carrying capacity with the high cost of development means that it is currently more realistic to place water points 10 km apart (i.e. a 5 km grazing radius), starting with the most productive land types first. 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).

5.5.4.2 The implementation of this practice

Water points should be sited away from fence lines and areas that cattle favour (e.g. creek lines, riparian areas, shady sites) whenever possible as this may help in reducing the extent to which cattle congregate around the water for lengthy periods and reduce the possibility for these areas to be overgrazed. Water points should also be sited away from sensitive parts of the landscape, such as soils that are highly erodible. Studies in semi-arid rangelands in 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 4). This creates large sacrifice areas around the water and can negatively impact on production because animals need to walk farther to access feed. Centrally located water points dramatically increase the watered area of the paddock and result in lower effective stocking rates within 5 km of water (Table 4). 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 4. An example of the impact of water point placement on effective grazing area and stocking rate



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

5.5.4.3 Considerations/caveats

There will be regional differences in how many water points are needed and how far apart they should be placed. These differences will be influenced by the productivity and heterogeneity of the land, 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 above recommendations. This is not so true in the Barkly where the rate of development has been limited due to problems in finding underground water, variations in water quality and supply, the high costs of drilling and equipping waters and the expense of reticulating water. Producers at recent workshops have confirmed that they are concentrating their efforts on their most productive country due to the high costs of development (Scott 2009; White and Walsh 2010). Some land may be undeveloped and thus ungrazed because of its low pasture value and installing a new water point to make this area more readily accessible to cattle may not be financially worthwhile.

In a paddock that has multiple water points, cattle will not necessarily distribute themselves evenly amongst them. In paddocks carrying high stock numbers, this can result in large congregations of cattle on certain water points. Research suggests that in order to balance land condition and animal production outcomes, the number of animals using a water point in the Barkly should probably be limited to approximately 300 head for the most productive land types if they are grazed in a continuous grazing regime (McIvor et al. 2010).

It is also important to note that despite having improved access to water, cattle will continue to graze paddocks unevenly to some extent. Other techniques to attract cattle to under-utilised areas should thus be implemented. A recent trial conducted at Rockhampton Downs Station in the Barkly region found that cattle could be trained to use alternate water points in order to achieve more even use of the paddock (Scott et al. 2009). The strategic location and regular re-location of supplements, and strategically burning patch grazed areas or areas with an accumulation of old senescent pasture may also help to distribute grazing more evenly.

If fire is used to remove accumulations of old feed, careful management is required after burning. It is generally considered important that perennial grasses in burnt areas be allowed to re-grow so there is a reasonable body of feed before they are grazed again after burning. Burning in the dry season will usually mean the paddock cannot be used for the remainder of the year since the cattle will concentrate on these areas and potentially kill re-shooting perennial grasses if soil moisture is available.

In large paddocks that only have one water point, stock have to be removed to accumulate fuel and then have to be kept out of the paddock to allow pasture to recover. Having more than one water point in a paddock can thus increase options for prescribed burning because cattle can be moved to an alternative water point to allow sufficient fuel to accumulate in another area. Additional water points may also allow unburnt parts of the paddock to be used after others have been burnt. The development of new water points in a paddock also provides options for spelling overgrazed areas around older water points.

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) to protect these resources. A general recommendation is that up to 10% of a property should be set aside to conserve biodiversity.

5.5.5 Essential management action 2: reduce paddock size

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

5.5.5.1 Evidence supporting this management action

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. Reducing the size of large paddocks provides better control over where cattle graze and improves the effective use of available forage. This potentially allows an increase in the number of stock carried with reduced risk of land degradation caused by large concentrations of livestock in favoured areas.

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 one 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. 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 areas.

Reducing paddock size to that which approximates the usual grazing radius of cattle (i.e. the distance from water that encompasses the majority of cattle grazing) could be considered the ideal for many of the more extensive regions as it will mean most areas in a paddock are accessible to cattle. Assuming a grazing radius of 3 km, this would translate to a paddock size of about 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 watering points had been established. The research showed that reducing paddock size did not substantially improve the uniformity of grazing at smaller scales (e.g. patch scales) within paddocks. This suggests there is little value in reducing paddock size below that where all parts are accessible to cattle (i.e. no smaller than 30 to 40 km^2) in the more extensive regions of northern Australia. Producers in the Barkly have indicated that 30 to 50 km^2 is probably an ideal minimum paddock size. However, there is some resistance to creating smaller paddocks due to the cost of ongoing maintenance, such as grading and fence repairs. A trial has recently commenced on Mungabroom Station in the Barkly to investigate the land condition, pasture productivity and animal production performance of intensive infrastructure development and rotational grazing (Walsh, unpublished). The trial area is situated predominantly on black soil plains and is about 1800 km^2. This area has been fenced into paddocks ranging in size from about 4 km^2 to 16 km^2, with two water points per paddock. The area is used to graze a large herd (>5000 young bulls) in an intensive, short-duration rotation system throughout the year. The results of this trial are expected to add considerably to our knowledge of infrastructure development and grazing management in the region.

5.5.5.2 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. 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 congregate on bluebush swamps) can be used to inform paddock design.

In other parts of Australia, fencing highly different land types into different paddocks is often recommended as a strategy to minimise preferential grazing. However, in the Barkly, having black soils and red soils together in the same paddock is desirable for animal performance. In the wet season, cattle prefer to stay off the boggy black soils and spend their time on higher red soil country. However, because red soil pastures typically have lower carrying capacity, care needs to be taken to ensure that stocking rates are managed to prevent overgrazing on these areas.

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 to 40 km^2) since this would further increase the extent of the area grazed, reduce the potential for excessive overgrazing around water points (by reducing the number of cattle per water point), and provide some safety and flexibility should one water point break down. Allowing one water point per 20 to 25 km^2 of land area is recommended to maximise the area accessible to cattle. Producers in the Barkly are increasing the number of water points per paddock to achieve such benefits as being able to spell bores without removing cattle from the entire paddock and also the increased peace of mind that comes from having back-up water supplies in paddocks (Scott 2009; Scott et al. 2010; White and Walsh 2010).

5.5.5.3 *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 subdivision of 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. There is certainly a need to investigate alternative fencing options that minimise installation and maintenance costs.

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 larger 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 result in completely even use within a paddock. Some areas may still not receive much use and some areas will be heavily used. However, the rate at which overgrazed areas grow will be slower. As well as reducing paddock size, the use 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) have identified knowledge gaps related to the science and management of stocking rates, pasture spelling, prescribed burning and infrastructure development. The following needs relevant to the Barkly were identified via a comprehensive literature review (McIvor et al. 2010), the bio-economic modelling (Scanlan 2010) and two workshops held in the region (Scott 2009; White and Walsh 2010):

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. Recommended stocking rates for different land types in different land condition classes.

3. A better understanding of the pros and cons of conservative set-stocking versus variable stocking rate strategies in terms of economic performance and land condition in the Barkly.

4. A long-term demonstration site investigating the practical aspects of matching stocking rate to carrying capacity.

5. An analysis of the impact of the trend of increasing animal size on food intake and conversion efficiency and its effect on the number of cattle that can be run.

6. Practical options for increasing production efficiency (i.e. managing stocking rates to improve nutrition per head).

7. The development of more reliable seasonal forecasting tools.

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 four-paddock rotation with wet season spelling whereby additional cattle are either removed or allocated to non-spelled paddocks based on forage budgeting.

2. Determining the relative contributions of grass regrowth and seedling recruitment to pasture recovery under spelling in order to improve the modelling of responses in GRASP.

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

4. An increased understanding of the benefits and costs of spelling during the early growing season, the whole growing season and the non-growing season.

5. An assessment of the relative performance of destocking versus wet season spelling versus conservative set stocking for improving land condition.

6. A study to determine whether it is more profitable to run more adult equivalents under a spelling regime versus producing more kilograms per head using a lower stocking rate.

7. An analysis of the opportunity costs for reclaiming land in poor condition compared with keeping it in good condition.

8. Model simulations to compare the performance of a range of rotational grazing systems.

It should be noted that demonstration sites exploring spelling, stocking rate management and water point development commenced on Alexandria Station in 2011 and on Mungabroom Station in 2012.

6.3 PRESCRIBED BURNING

Although prescribed burning is considered by some producers to be a tool of minor potential in the Barkly region, the following needs were identified:

1. Whether fire is useful for removing rank pasture in newly-developed country prior to grazing.

2. The economic costs and benefits of using burning versus other strategies to achieve particular outcomes.

6.4 INFRASTRUCTURE DEVELOPMENT

1. How to improve the uniformity of grazing within paddocks without the need for more fencing.

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

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

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

5. Behavioural aspects of cattle in relation to water points, such as 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.

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

7. 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.

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