Sustainable management of the Burdekin grazing lands

A technical guide of options for stocking rate management, pasture spelling, infrastructure development and prescribed burning to optimise animal production, profitability, land condition and water quality outcomes.

Queensland Government

Disclaimer

The report is provided in good faith on the understanding that the information is not used out of the context explained within the guide. Not all practices, or the many variations of these practices, have been objectively evaluated, or their impacts measured. 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 need to be considered in the context of the whole property. Local knowledge and experience combined with the biological and economic modelling have therefore been very important in helping develop the options and ideas in this technical guide. As there will be some degree of uncertainty about what practices will work best in any particular situation, it is important to see the options and ideas as input to the decision-making process and not as set prescriptions or recipes.

Citation

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Photo (front cover): Bullocks 'Liontown' Charters Towers, courtesy Bob Shepherd, Department of Agriculture, Fisheries and Forestry

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A technical guide of options for stocking rate management, pasture spelling, infrastructure development and prescribed burning to optimise animal production, profitability, land condition and water quality outcomes.

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Executive summary

This guide is a technical resource designed to be used by advisors working with producers to improve grazing management in the grazing lands of the Burdekin catchment in Queensland. An earlier unpublished version was produced in the Northern Grazing Systems (NGS) initiative. The aim of the earlier version was to demonstrate how best to manage grazing country for beef production by optimising both pasture sustainability and return on investment. This version incorporates water quality outcomes from sustainable management of grazing lands. It is planned that over time, the guide will be improved by the information and experiences shared by producers, their advisors and researchers.

The guide starts with background information on land condition (including the ABCD land condition framework), followed by descriptions of the main land types in the Burdekin important for grazing and information on erosion, soil loss and water quality. The current situation in the Burdekin (in terms of land use) and the management practices used by producers are described.

The major part of the guide is the information on options for grazing land management. This is developed around nine aims common to most properties in the Burdekin grazing lands. These aims are:

1. maintaining land in good (A and B) land condition
2. improving land in poor (C) land condition
3. stabilising and recovering land in very poor (D) land condition
4. improving frontage country and wetlands
5. reducing grazing pressure in selectively-grazed areas
6. locating water points to even out grazing
7. minimising erosion when locating infrastructure
8. minimising woody plant problems
9. managing chemicals and fertilisers

There is a separate chapter for each aim with information presented on:

- situation (description of land condition including pasture condition, ground cover and forage production)
- factors to consider (underlying causes, inferences about past management and considerations for future management)
- management responses - the key practices and their rationale
- management options – specific management options that can contribute to achieving better practice including
    - evidence-base for these options
    - how to implement them
    - trade-offs, caveats, uncertainties and other issues associated with this information.

Each chapter contains a toolbox with tools, further reading and workshops to aid readers seeking further information. There is also a general toolbox; list of botanical and common names for pasture plants, trees and shrubs; and a glossary of terms.

Chapter 1. Introduction

This technical guide is designed to inform and improve grazing management in the grazing lands of the Burdekin catchment in Queensland (refer to Figure 1 showing the Burdekin Dry Tropics). It focuses on four key management techniques: stocking rate, spelling pasture, burning, and using water points and fences to manage grazing, but also considers other techniques. Particular ways of using these techniques are applied to nine major aims or objectives of landholders. Although stocking methods (e.g. continuous, rotational, cell) per se are not considered, the information is relevant to deciding on stocking methods for a property and how the techniques can be incorporated into management. The guide is a technical resource for use by those working with producers to improve the management of grazing lands for beef production.

An earlier version of this guide was produced in the Northern Grazing Systems (NGS) initiative. NGS was developed and implemented as a partnership between Meat and Livestock Australia (MLA), CSIRO, AgriScience Queensland (Queensland Department of Agriculture, Fisheries and Forestry, formerly DEEDI), the Northern Territory (NT) Department of Resources, and the West Australia (WA) Department of Agriculture and Food. This initiative was designed to ensure that the beef cattle industry in Queensland, the NT, and northern WA derive the full benefit from research on how best to manage grazing country for beef production to optimise both pasture sustainability and return on investment. This early version was then revised and expanded. Information about how good grazing practices also protect water quality and reduce the risk of soil loss to the Great Barrier Reef has been incorporated.

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

The technical guide will be used by advisors working with producers to increase awareness, understanding, and uptake of improved grazing practices and, over time, the guide itself will be improved by the information and experiences shared by producers, their advisors, and researchers.

How the guide was developed

This technical guide was developed by combining information from five major sources:

- A review of reports and other publications from completed research on grazing land management relevant to northern Australia (Queensland, Northern Territory and the Kimberley and Pilbara rangelands of Western Australia), with an emphasis on studies from the Burdekin grazing lands. This review focused on four themes: managing stocking rate, pasture spelling, burning, and strategically installing fences and water points. A set of principles and guidelines for management were developed. These are presented in Table 5 and drawn on when developing the management responses and options.

- Outputs from testing different management options via computer models. Effects of stocking rate, pasture spelling and fire upon pasture and animal productivity were simulated with the GRASP model. The pasture and animal production from GRASP was then used in an economics spreadsheet model called ENTERPRISE to assess impacts on the economics of a beef enterprise with a herd and paddock structure typical of the region. This modelling provides a way of extrapolating responses measured in a grazing trial to a wider range of land types and weather conditions. It also provides a way to test multiple variations in grazing management that would be expensive and time-consuming to test on the ground. This helps to identify the most cost-effective practices.
- The combined knowledge and experience of beef 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, were captured. This was done over two workshops and via direct input to reports including this guide. This local input also helped develop plans for the next phase of the NGS initiative in the region and identified and prioritised information gaps.
- Additional information on the impacts of grazing management on grazing land condition, on soil loss from run-off and soil erosion was added later.
- The entire report was reviewed for the Reef Protection Program by the Grazing Management Systems Working Group at workshops and other experts. The Working Group consisted of representatives from RPP, Department of Environment and Heritage Protection (DEHP); Rural Leasehold Land Strategy (Delbessie Agreement) Department of Natural Resources and Mines, Department of Agriculture, Forestry and Fisheries (DAFF); NQ Dry Tropics NRM and Reef Catchments; and AgForce.

Using the guide

The guide is directed at extension officers and other personnel working with producers managing grazing lands in the Burdekin. It was designed to be technical and comprehensive so that it captures the information, insights, ideas and uncertainties that arose from the research findings, modelling outputs and the views of producers and technical specialists in the region.

The guide can be used in several ways:

- For operatives working with producers, as a:
  - means of improving their understanding of key grazing management practices and their awareness of the evidence base that underpins these practices
  - source of ideas for management strategies that will most cost-effectively address a particular issue or objective
  - guide to which issues/practices and variations of these, deserve additional extension activity via demonstration sites or other processes
  - 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 EDGE*network* Grazing Land Management (GLM) workshop materials, fact sheets and web information
- As a means of capturing new insights and information from interactions with producers, property case studies and demonstrations, additional research and additional biological and economic modelling.

The guide has been developed around nine aims relating to the management of most properties in the Burdekin grazing lands. These are:

1. maintaining land in good (A and B) land condition
2. improving land in poor (C) land condition
3. stabilising and recovering land in very poor (D) land condition
4. managing frontage country and wetlands
5. reducing grazing pressure in selectively-grazed areas
6. locating water points to even out grazing
7. minimising erosion when locating infrastructure
8. minimising woody plant problems
9. managing chemicals and fertilisers

For each aim, information is presented on:

- Situation (description of land condition including pasture condition, ground cover, and forage production)
- Factors to consider (underlying causes, inferences about past management, and considerations for future management)
- Management responses - the key practices and their rationale
- Management options – specific management options that can contribute to achieving better practice including:
  - evidence-base for these options
  - how to implement them
  - trade-offs, caveats, uncertainties, and other issues associated with this information.

Chapter 2. Current understanding of grazing land condition

Grazing land condition (referred to as 'land condition') is a measure of the health of grazing lands and is related to the capacity of grazing land to produce useful forage (and hence animal production), runoff, and soil erosion.

ABCD land condition

Land condition is affected by soil, pasture and woodland condition.

- **Soil condition** determines the capacity of the soil to absorb and store rainfall, to store and cycle nutrients, to provide habitat for seed germination, and plant growth and to resist erosion.
- **Pasture condition** determines the capacity of the pasture to capture sunlight and convert its energy into palatable green leaf, to use rainfall efficiently, to conserve soil condition, and to cycle nutrients.
- **Woodland condition** determines the capacity of the woodland to grow pasture, to cycle nutrients, and to regulate ground-water.

Perennial grasses are a key determinant of land condition. Perennial plants live for more than a year (and often for a number of years), regenerate from tussocks as well as seed and hence are more able to protect the soil from erosion compared to annuals. In contrast, annual plants complete their life cycle from germination to death within a season or year. They can only regenerate from seed and tend not to survive into the dry season. This leaves bare soil susceptible to erosion. In general perennial grasses have deeper root systems than annual grasses and this can aid water entry into the soil.

Perennial grasses differ in their value. The most important and preferred are the **3P grasses** – those that are productive (produce most forage), perennial (live for more than one year) and palatable (well grazed by stock).

Land condition can be classified into four broad categories:

'A' condition land

Good or 'A' condition land has all the following features:

- Good coverage of perennial grasses dominated by those species considered to be 3P grasses for that land type; organic ground cover greater than 50% at the end of the dry season. Most land types in good condition will have at least 50% and often above 70% ground cover
- Few weeds and no significant infestations
- Good soil condition: no erosion, good surface condition
- No sign, or only early signs, of woodland thickening.

Land in this condition is associated with minimal run-off and high infiltration rates. When there is run-off after large rainfall events, run-off generally has a low concentration of sediment.

'B' condition land

Fair or 'B' condition land has at least one or more of the following features, but otherwise is similar to A condition:

- Some decline of 3P grasses; increase in other species (less favoured grasses, weeds) and/or organic ground cover of 40–50% at the end of the dry season

- Some decline in soil condition; some signs of previous erosion and/or current susceptibility to erosion is a concern
- Some thickening in density of woody plants.

'C' condition land

Poor or 'C' condition land has one or more of the following features, but otherwise is similar to B condition:

- General decline of 3P grasses; large amounts of less favoured species and/or organic ground cover of 20–40% at the end of the dry season
- Obvious signs of past erosion and/or current susceptibility to erosion is high
- General thickening in density of woody plants.

'D' condition land

Very poor or 'D' condition land has one or more of the following features:

- General lack of any perennial grasses or forbs, organic ground cover less than 20% at the end of the dry season
- Severe erosion or scalding, resulting in hostile environment for plant growth
- Thickets of woody plants cover most of area.

On any land type, each of the condition categories may be represented by more than one form or 'state'. For example, condition A land may be represented by different mixes of 3P grasses. Similarly, condition D land may be represented by lack of 3P grasses, or by a high density of woody plants, or by extensive loss of soil condition. Examples of land types in A, B, C and D condition are given in Karfs *et al*. (2009b). The photos (right) show the land condition and ground cover of goldfields country - red soils land type in good (A), fair (B), poor (C) and very poor (D) condition.

The four broad condition categories provide a means of ranking these 'states' with respect to their ability to grow useful forage and for water quality which are both highest for A condition. A condition land grows more forage and has high cover, low run-off and no erosion. D condition land grows the least forage and has low cover, high run-off and severe erosion. For both pasture production and water quality B and C condition are intermediate.

Goldfields country – red soils in A, B, C and D land condition

Photos from Karfs *et al*. (2009b)

Good (A) condition ~ Ground cover ›80%

Fair (B) condition ~ Ground cover ›40%

Poor (C) condition land ~ Ground cover 20-40%

Very poor (D) condition ~ Ground cover ‹20%

Land types and long term carrying capacity

There are 33 land types that are important for grazing in the Burdekin (from both the Burdekin and Desert Uplands Grazing Land Management (GLM) regions). They vary widely reflecting variations in climate and geology. Land types are listed in Table 1 including the preferred 3P grasses for each land type, their susceptibility to erosion and safe utilisation rates.

Susceptibility to erosion refers to the assessed hazard for that land type based on erodibility of the soil, sub-soil characteristics and slope; the most likely forms of erosion (sheet, rill, gully); and management factors that may increase the risk.

Safe utilisation (Quirk and McIvor, 2003) is the maximum rate of average annual use consistent with maintaining or encouraging good land condition e.g. a safe average utilisation rate of 30% for the black basalt land type implies that grazing should be managed so that the average level of pasture utilisation is 30%. Note that these recommended rates usually assume there is little effect on the evenness of grazing from either selective grazing of land types or distance from water.

In the bio-economic modelling conducted as part of the NGS project and referred to in later chapters, black basalt, goldfields and yellowjacket land types have been chosen to represent high, medium and low soil fertility levels respectively, in this guide.

Long-term Carrying Capacity (LTCC), (Quirk and McIvor 2003) is the average number of animals a paddock can be expected to support over a five-ten year period. Land types provide the basis for pasture growth estimates used to calculate long-term carrying capacity within paddocks and for comparing grazing management options. Other considerations for calculating LTCC include condition of land types, climate, evenness of use by cattle, grazing strategy or method and goals for animal production and land condition.

Long term carrying capacity is calculated as follows:

Expected pasture growth for an average year (kg/ha) x utilisation rate (%) divided by forage demanded per Adult Equivalent per year (kg) = Adult Equivalents/ha in the year

Table 1. Land types in the Burdekin grazing lands (Burdekin and Desert Uplands GLM regions), their susceptibility to erosion and safe utilisation rates. This table was adapted from 'Land types of Queensland' on the FutureBeef website (futurebeef.com.au) 2012 and Department of Environment and Resource Management (2010).

Brudekin GLM region			
Land type	**Preferred 3P grasses**	**Erosion susceptibility**	**Safe utilisation rate (%)**
Black basalt	Queensland blue grass, curly blue grass, black spear grass, curly and hoop Mitchell grass, tall cup grass	Limited soil erosion hazard. Prone to rill and gully erosion along tracks and fence lines and on sloping lands.	30
Brown basalt	desert blue grass, black spear grass, kangaroo grass, curly blue grass, giant spear grass, plume and brown sorghum		30
Clayey alluvials	Queensland blue grass, desert bluegrass, curly blue grass, curly and hoop Mitchell grass, tall cup grass, native millet, green couch* (naturalised)	Variable soil erosion hazard. Prone to rill and gully erosion, highly erodible along tracks, fence lines and drainage lines.	30% (native); 35% (sown).
Downs	hoop and curly Mitchell grass, curly blue grass, king blue grass, Queensland, blue grass, native millet, buffel grass*	Limited soil erosion hazard. Prone to rill and gully erosion along tracks and fence lines and on sloping lands.	25
Goldfields country – black soils	desert blue grass, Queensland blue grass, curly blue grass, buffel grass*, urochloa*, black spear grass, kangaroo grass		25
Goldfields country – red soils	desert blue grass, forest blue grass, curly blue grass, buffel grass*, urochloa*, cotton panic, black spear grass, kangaroo grass	Generally limited soil erosion hazard. However, past land uses, including mining and grazing, have had a widespread legacy effect in terms of sheet, rill and gully erosion.	25
Loamy alluvials	desert blue grass, black spear grass, kangaroo grass, cotton panic, giant spear grass, green couch* (naturalised)	Variable soil erosion hazard. Highly erodible where sub-soil is exposed, particularly along fence lines, tracks and drainage lines and on sloping lands. Prone to gully erosion adjacent to major watercourses.	30% (native); 35% (sown).
Narrow- leaved ironbark on deeper soils	black spear grass, kangaroo grass, desert blue grass, hairy panic, forest blue grass, spinifex (west)	Variable soil erosion hazard. Highly erodible where sub-soil is exposed, particularly along fence lines, tracks and on sloping lands and drainage lines.	25
Red basalt	desert blue grass, black spear grass, kangaroo grass curly blue grass, giant spear grass, plume and brown sorghum	Limited soil erosion hazard. Prone to rill and gully erosion along tracks and fence lines and on sloping lands.	30
Blackwood scrubs on structured clays	desert bluegrass, buffel grass*,curly blue grass, brigalow grass	Limited soil erosion hazard. Prone to sheet, rill and gully erosion along tracks and fence lines and on sloping lands.	25% (native); 30% (sown).
Box and napunyah	soft spinifex, desert blue grass, kangaroo grass	Variable soil erosion hazard. Highly erodible dispersible soils wheresub-soil is exposed, particularly along fence lines, tracks and on sloping lands and drainage lines.	15
Box country	desert bluegrass, curly blue grass, black spear grass, kangaroo grass, cotton panic, buffel grass*, urochloa*	Variable soil erosion hazard. Highly erodible where sub-soil is exposed, particularly along fence lines, tracks and on sloping lands and drainage lines.	25
Brigalow gidgee scrubs	Queensland blue grass, curly blue grass, native millet, curly Mitchell grass, buffel grass*, brigalow grass	Limited soil erosion hazard. Prone to rill and gully erosion along tracks and fence lines and on sloping lands.	30% (native); 35% (sown).
Narrow-leaved ironbark on shallower soils	black spear grass, kangaroo grass, desert blue grass, hairy panic, forest blue grass, golden beard grass	Moderate soil erosion hazard. Prone to sheet, rill and gully erosion on sloping lands.	20
Silver-leaved Ironbark	golden beard grass, desert bluegrass, black spear grass kangaroo grass, Queensland blue grass (south), native millet (south – clay soil), forest blue grass	Limited soil erosion hazard. Prone to sheet, rill and gully erosion along tracks and fence lines and on sloping lands.	25
Yellowjacket with other eucalypts	Soft Spinifex, black spear grass, silky umbrella grass, hairy panic, giant spear grass, cotton panic, kangaroo grass, plume sorghum, golden beard grass		20
Blackwood scrubs on massive soils	Desert blue grass, brigalow grass, bull Mitchell grass, windmill grasses	Very high soil erosion hazard. Particularly prone to scalding, gully and tunnel erosion along tracks, fence lines and on sloping lands.	15
Lancewood-bendee-rosewood	cotton panic, tableland couch, hairy panic, kangaroo grass, spinifex	Generally low soil erosion hazard, apart from areas with steep broken slopes	10
Softwood scrub	Buffel grass*, urochloa*	Limited soil erosion hazard. Prone to sheet, rill and gully erosion along tracks and fence lines and on sloping lands.	30% (native); 35% (sown).
Ranges	Black spear grass, giant spear grass, kangaroo grass, blady grass, buck spinifex	Limited soil erosion hazard. Prone to rill and gully erosion along tracks and fence lines and on sloping lands.	10

*Denotes non-native species

Desert Uplands GLM region			
Land type	**Preferred 3P grasses**	**Erosion susceptibility**	**Safe utilisation rate (%)**
Box country	black spear grass, kangaroo grass, forest blue grass, desert blue grass, golden beard grass, buffel grass*, soft spinifex	Variable soil erosion hazard. Highly erodible where sub-soil is exposed, particularly along fence lines, tracks and on sloping lands and drainage lines.	25
Coolibah flats	buffel grass*, curly Mitchell grass, black spear grass, forest blue grass golden beard grass, kangaroo grass, Queensland blue grass	Variable soil erosion hazard. Highly prone to sheet erosion despite gentle slopes.	25
Downs country	Mitchell grasses (curly, barley, bull) , Queensland blue grass, native millet		25
Frontage	black spear grass, desert blue grass, kangaroo grass	Variable soil erosion hazard. Prone to rill and gully erosion, highly erodible along tracks, fence lines and drainage lines.	25
Ironbark country	black spear grass, soft spinifex, kangaroo grass, Queensland blue grass, desert blue grass, forest blue grass, curly blue grass, golden beard grass	Variable soil erosion hazard. Prone to sheet erosion.	25
Channels and swamps associated with major streams	green couch grass, bull Mitchell grass, forest blue grass, desert blue grass, golden beard grass, kangaroo grass	Limited soil erosion hazard. Prone to streambank erosion during peak flow periods.	25
Frontal dunes	marine couch grass, buffel grass*	High erosion hazard. Prone to wind erosion, limited sheet and rill erosion due to high soil permeability.	15
Hard ironbark country	kangaroo grass, soft spinifex, buck spinifex	High erosion hazard. Prone to sheet erosion and shallow gullying.	20
Scrubs on deep clays	buffel grass*,bull Mitchell grass, curly Mitchell grass, blue grasses blue grasses (e.g.desert)	Limited soil erosion hazard. Prone to sheet, rill and gully erosion along tracks and fence lines and on sloping lands and drainage lines.	30
Scrubs on shallow clays	Mitchell grasses (barley, bull, hoop, curly)), desert blue grass, Queensland blue grass, forest bluegrass, silky browntop		25
Yellowjacket country plus/ minus wattles	soft spinifex, kangaroo grass, black spear grass, golden beard grass, forest blue grass	Limited soil erosion hazard. Prone to sheet, rill and gully erosion along tracks and fence lines and on sloping lands.	20
Jump-ups	soft spinifex, buck spinifex, kangaroo grass, golden beard grass, Seca stylo*	Generally high erosion hazard associated with steep slopes.	15
Lakebeds	marine couch, saltbush	Generally low erosion hazard. Can be prone to wind erosion along open areas.	10

*Denotes non-native species

Erosion, soil loss and risk to water quality

Soil erosion is the detachment and movement of soil or rock by water wind, ice or gravity. In the Burdekin catchment, water is the major form of erosion and depends on run-off. More detailed accounts of the information in this section are contained in Nelson and Roth (2004) and Roth *et al.* (2004). Some soil loss is natural but it has been estimated that erosion rates in the Burdekin are between five and ten times greater than they were before European settlement (McCulloch *et al.* 2003). Soil loss leads to pasture degradation and increases the risk of sediment from soil entering waterways and impacting on the health of the Great Barrier Reef.

Infiltration and run-off

Rain that falls on the soil surface either enters the soil (infiltration) or runs off and the ratio of these processes is an important influence on production and off-site impacts e.g. water quality.

Run-off occurs when rainfall rate is greater than soil infiltration rate or the soil is saturated. It is affected by soil porosity, soil moisture, rainfall intensity and ground cover. There is a close relationship between cover and infiltration. As cover increases infiltration increases but the relationship is not simple and depends on the size of the rainfall event. In a study at Cardigan (McIvor, Williams *et al.* 1995), in small rainfall events (total <50 mm and intensity <15 mm/h) run-off decreased rapidly as cover increased and only small cover levels (40%) were needed to reduce run-off to a low level. As the size of the rainfall event increased, greater cover levels were required to reduce run-off and for large events (total >100 mm and intensity >45 mm/h) cover had no effect on run-off. Pasture is a major source of ground cover and is strongly influenced by grazing.

Types of erosion

There are three sources of sediment – erosion of hillslopes, gullies and streambanks.

Hillslope erosion

Hillslope erosion includes surface wash and rill formation. Rain drops dislodge soil particles from the soil surface making them available to be moved. The rate of movement then depends on:

- hillslope gradient
- rainfall amount and intensity
- soil erodibility
- ground cover and soil surface condition

High rates of hillslope erosion are likely to occur (Roth *et al.* 2004) where:

- ground cover is less than 50%
- slopes are steeper than 2%
- rainfall is intense

Scalded land showing rill erosion; rills form when water concentrates into flow paths, delivering soil down the slope.

Hillslope transport capacity is largely controlled by flow velocity and flow depth and the particle size of the sediment (sand needs fast flow but slow movement is sufficient to move clay and silt). Flow velocity is determined by slope, flow depth, surface roughness, and the presence of anything to impede the flow. Attaining adequate ground cover is the major method of reducing hillslope erosion. Cover reduces the amount of soil detached by raindrops, increases the flow depth, and reduces flow velocity. This reduces the amount of soil detached by flowing water and the capacity of water flow to transport sediment.

Studies in both the Burdekin and Fitzroy catchments (Silburn *et al.* 1992; McIvor, Williams *et al.* 1995; Scanlan *et al.* 1996) have shown that soil movement increases rapidly as cover levels drop below 40% and McIvor, Williams *et al.* (1995) recommended that managers should maintain at least 40% ground cover although this would still allow large losses of suspended sediment in large rainfall events.

In later studies Bartley *et al*. (2010) extended these findings and showed distribution of cover was important as well as the overall level. In a small (14 sq km) catchment in the Upper Burdekin, 97% of the fine sediment came from 3% of the catchment and most of this came from areas where ground cover was <10%.

Roth (2004), using rainfall simulation, related infiltration rate and sediment concentration to ground cover for a range of duplex and gradational soils (all hard-setting) with a range of soil surface condition. There was a wide spread of values particularly for infiltration rate at high cover and sediment concentration at low cover. Therefore, more than ground cover alone is needed for predictions and he showed simple observable indicators of soil surface condition could be used.

For low (<25%) and medium (25-75%) cover levels these were erosion features, deposition layer, gravel pavement and cryptogam cover; for high (>75%) cover the indicators were level of biological activity (incorporation of litter, presence of macropores, frequency of animal castings, enhanced micro-relief). These features could effectively differentiate infiltration and sediment concentration in run-off within the broad cover classes. He concluded that while the cover threshold of 40% previously suggested was probably sufficient to significantly reduce soil and nutrient loss, a long-term target cover level of 75% would be required for recovery of soil hydrological and biological function with a significant increase in infiltration. This cover level may be difficult or impossible to achieve on some land types.

Gully erosion

Gully erosion is an advanced stage of rill erosion and occurs when run-off concentrates in drainage lines or narrow channels and incises into the subsoil removing soil to a considerable depth. It can be a major problem where high rates of water flow are combined with dispersive sodic soils and large amounts of water concentrate in steep drainage lines.

Triggers to initiate gully erosion are increased run-off and features that concentrate flow e.g. cattle tracks, roads, drains.

Most gullies extend up slope as a result of headwall migration. However, it is the collapse and slumping of the sidewalls which usually contributes the greatest amount of soil loss. Strategies for reducing the concentration of run-off and hence limiting gully erosion relate to maintaining good ground cover e.g. by fencing off frontages to manage grazing pressure, especially upslope from the gully and managing the run-off from tracks and other structures.

High rates of gully erosion are likely to occur (Roth *et al*. 2004) where:

- catchment ground cover is less than 50%
- slopes are around 2%
- soils have dispersible clay subsoils

Gully erosion.

Streambank erosion

Streambank erosion depends on stream power which is a function of river discharge (high erosion with large, fast flows) and the vegetation protecting the bank. Unconsolidated alluvial deposits which may be common on river frontages are highly erodible. A healthy stand of mixed vegetation has roots through the soil and these bind both the surface and sub-soil; maintaining this vegetation is important for minimising streambank erosion.

High rates of streambank erosion are likely to occur (Roth *et al*. 2004) where:

- stream velocities exceed 2 m/s
- there are rivers and large creeks
- riparian vegetation is sparse

Streambank erosion.

Major sources and risk areas for sediment loss

It is important to determine which types of erosion are contributing most sediment so that restoration strategies can be targeted appropriately. Modelling initially suggested hillslope erosion was the dominant source of sediments in the Burdekin catchment contributing 67% of the total compared to 27% from gullies and 5% from streambanks (Prosser *et al*. 2002). Although hillslope erosion can dominate sediment loads in drought years when cover is low (Bartley *et al*. 2007), channel erosion appears to dominate sediment yields in the long term contributing 60% of the total (Bartley *et al*. 2010).

It is likely that removal of cover on highly dispersive sodic soils is the dominant cause of gully expansion. Wilkinson *et al*. (2012) used sediment tracing techniques to identify contributions of surface versus subsurface soil in the Burdekin catchment and found between 77% and 89% of the fine sediment loss was derived from subsurface soil sources with sediment sources in close proximity to the drainage network. They concluded gully erosion is likely to be the dominant subsurface erosion process although streambank and hillslope erosion could not be discounted.

Sampling over five wet seasons (2006 to 2010) determined that between 900 and 14,800 kt/year of fine sediment passed the most downstream gauge of the Burdekin River (Bainbridge *et al*. 2010; Bainbridge *et al*. in prep). Monitoring of the suspended sediment suggests that the Upper Burdekin and Bowen sub-catchments dominate the total export of sediment and that these catchments are also the main sources of fine (‹10 μm) sediment.

The proportions from different sub-catchments can vary widely between rainfall events depending on the distribution of rainfall over the sub-catchments. Some sediment (particularly the larger particles) from streams above the Burdekin dam will be trapped behind the dam wall.

Toolbox

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Chapter 3. Current situation in the Burdekin

For this guide, the Burdekin grazing lands are considered to be those in the Burdekin Dry Tropics NRM region. This region covers the catchment of the Burdekin River and also the coastal streams in the Townsville-Bowen area (Figure 1) The Burdekin catchment is on the eastern side of the Great Dividing Range extending from north of Greenvale to south of Alpha. It follows the coastline for approximately 250 kilometres (km) and extends about 350 km inland from the coast covering an area of approximately 14.1 million hectares (ha). This area includes all of the Charters Towers Regional Council area and parts of the Whitsunday, Isaac and Barcaldine Regional Council areas.

The north of the Burdekin catchment is dominated by eucalypt woodlands on low to moderate fertility soils although there are important areas of more fertile basaltic soils that support both woodlands and open grasslands. In the south of the catchment there are large areas of brigalow-gidyea scrubs that have been extensively cleared and developed with sown pastures.

Most (90-95%) of the land area is used for extensive cattle grazing. There are an estimated 827 landholders grazing cattle in the Burdekin region. The majority of properties are owned by families under a mix of lease-hold and free-hold tenure. More than 70% of properties have been owned by the same family for an average of 35 years. There are estimated to be 500 commercial beef producing businesses in the region.

Property sizes in the Burdekin region range from 10,000 to 50,000 hectares (ha), with an average of approximately 30,000 ha. It is estimated that 95% of each property is useable for grazing on average. The average beef property more than doubled in size between 1977-78 and 2001-02. The cattle number per property ranges from 2000 to 5000 head, with an average of 3400 including 1200 breeders and a carrying capacity of 4-20 ha/animal.

Figure 1. The Burdekin Dry Tropics catchment including Burdekin and Desert Uplands GLM regions.

There is also a significant irrigation area on the coastal plain between Giru and Bowen (mainly sugar-cane and horticulture). Tourism is a major industry. Mining for gold and base metals is important in the Charters Towers region.

The Burdekin River has the second largest catchment in Queensland and is of significance to the Great Barrier Reef lagoon, with the river entering the ocean at Upstart Bay.

Climate and land types

Rainfall is strongly summer dominant with 75-85% falling between the months of October and March. Average annual rainfall ranges from 500-800 mm within the region. Frosts are relatively common west of the coastal ranges.

The Burdekin grazing lands are dominated by wooded land types—especially ironbark–box woodlands and other eucalypt savannahs. Blackwood, brigalow and gidgee scrubs are common. Pastures include black spear grass, Aristida-Bothriochloa and spinifex. The majority of soils are low to moderate fertility although more fertile clay soils are relatively common (Tothill and Gillies 1992). The important land types are listed in Table 1 (Chapter 2) together with their preferred pasture species (3P grasses) and their susceptibility to erosion.

History of grazing use

The early explorers Leichhardt (in 1845), Gregory (1856) and Dalrymple (1860) reported that the area is 'undoubtedly capable of becoming one of the finest and largest pastoral and agricultural regions of Australia'. The establishment of Port Denison (now Bowen) in 1861 facilitated the opening of the country for settlement. Initial attempts to graze sheep generally failed and cattle grazing expanded quickly initially based on the growing local market of the gold mining settlements, export markets to the southern states and the opening of meatworks in Bowen and Townsville.

The cattle industry was set back in the late 1890s and early 1900s following the appearance and rapid spread of the cattle tick and the Federation drought. Major expansion of the local industry was not to occur until the 1950s with the opening of the American export market and good wet seasons. Subsequent developments including land resumptions during the 1950s and 1960s and ballots in the Charters Towers area, development of infrastructure (e.g. stock waters and fences) and favourable fiscal policies all served to foster rapid industry expansion and a trend away from 'cattle hunting' to more intensive management systems (McCullough and Musso 2004).

Tick resistant Brahman (*Bos indicus*) cattle breeds gradually replaced traditional European (*Bos taurus*) breeds such as Herefords and Shorthorns during the 1960s. Brahmans also proved more drought tolerant, being able to tolerate forage deficits for longer than European breeds. This change to Brahmans was gradual, with experimentation with the use of Brahman bulls from as early as 1910. Currently 90% of cattle in the Burdekin area are either Brahman or Brahman cross.

Improved productivity resulted from the introduction of tropically adapted sown pastures such as stylos (*Stylosanthes* spp.), and improvements in supplementary feeding technology – particularly the use of phosphorus. Improvements in animal husbandry and herd genetics have resulted in a steady decline in the cattle death rate since 1977-78. Improved ease of managing large numbers of cattle has come from changes in property management (e.g. the widespread use of road trains, motorbikes and helicopters).

Cattle numbers were at record highs by the early 1980s as a result of these improvements coupled with the beef price crash of 1974 and the run of wet seasons in the mid to late 1970s. Widespread land degradation occurred during the severe droughts of the 1980s as the beef industry had come to rely on the high number of cattle being run. Limited marketing options exacerbated the problem of cattle being retained despite low forage availability. Soil erosion, undesirable pasture composition changes and weed invasion became significant issues of grazing lands in the Burdekin. Cattle numbers declined substantially towards the end of the 1980s.

Live cattle export trade opportunities and the feedlot sector expanded in the 1990s, leading to the Burdekin area marketing younger and lighter animals. However, pasture decline continued during the severe drought years of the early 1990s. An assessment at the time (Tothill and Gillies 1992) estimated that 55% of the black speargrass pastures in Northern Queensland were degraded and 15% were assessed to be beyond recovery.

Current issues and trends

Substantial areas of the Burdekin are considered to be in poor condition, leading to reduced productivity, reduced ground cover, increased weed spread, increased run-off, increased erosion, and increased nutrient loss from soils that are already relatively infertile. This limits the productivity of the cattle industry and contributes to increased sediment discharge into the Great Barrier Reef lagoon. Increased sedimentation poses risks to reef ecosystems by shading out and smothering coral and seagrass beds, as well as to the tourism and fishing industries dependent on the Reef. The major sources of sediment are still subject to debate and estimates change as new research data become available (refer to Chapter 2). The debate is often complicated by an imperfect understanding of the main drivers of land degradation, although it is generally accepted that woodland thickening, woodland encroachment, invasive weeds, and long-term over-grazing contribute to land degradation and increased sediment generation.

Improvements in land condition will increase long-term pasture growth and livestock carrying capacity and ground cover and reduce soil erosion and the resulting nutrient loss and sediment discharge. Land condition should not be expected to improve quickly however, as land managers face the issues of variable rainfall, changing climatic conditions, established weeds, and relatively infertile soils.

Animal production constraints include variable herbage supply, low herbage quality during parts of the year, pests and diseases of cattle, and difficulties in achieving clean musters while the integrity of sub-divisional fencing used for herd and land condition management is often compromised by floods, fires and fallen timber.

The cattle industry is continually evolving in response to these constraints in the Burdekin. There is more emphasis on more intensive and deliberate management of the herd through practices like controlled mating, greater segregation of animals for mating and feeding, and early weaning. All of these have implications for property infrastructure (i.e. placement of fences, waters) and consequently for the sophistication of management practices that can be applied to the grazed landscape.

An assessment of grazing management practices for Reef Plan found up to 2009, 39% of graziers are using practices that are likely to maintain land in good to very good condition or improve land in lesser condition (State Government of Queensland, 2011).

Toolbox

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Dight, I 2009, *Burdekin Water Quality Improvement Plan*, NQ Dry Tropics, Townsville.

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Chapter 4. Current management practices in the Burdekin grazing lands

This section outlines the current application of different management practices in the Burdekin grazing lands.

Stocking rate management

Stocking rate (the number of animals per unit area for a given period) determines the level of pasture utilisation; its management is crucial to sustainable grazing management. Traditionally, set stocking, or an approximation of it, has been practised throughout most of the beef industry in northern Queensland. This involves running a consistent number of animals in a paddock through most years. Such management results in periods with relatively low utilisation in years with abundant pasture growth, interspersed with periods of relatively high utilisation in years with poor pasture growth. The sustainability of such a system depends on the stocking rate used and the frequency of high utilisation rates.

Industry consultation suggests that beef producers currently adjust cattle numbers in response to improving or declining rainfall patterns, as well as other factors such as market forces.

Accurate estimation of paddock area is a pre-requisite to calculating stocking rate - in 1994 only 40% of managers of 53 properties in the Burdekin rangelands surveyed by Gordon *et al.* (2008) reported they knew the size of their paddocks. With improved methods of estimating area (such as GPS, satellite imagery and property mapping tools), this number had increased to 74% by 2004. The majority of managers use satellite imagery and GPS (Table 2).

Table 2. Methods to measure paddock area used by graziers (from Gordon *et al.* 2008).

Measurement method	% of graziers using method^
Satellite imagery map	42
GPS	30
Manually	20
Other	5

^ Percentages will not necessarily add to 100% as people may be using more than one method

Pasture spelling

In 2004, 85% of managers were wet season spelling one or more commercial paddocks — an increase from 51% of the same managers in 1994 (Gordon *et al.* 2008 from data received from a survey of 53 properties in the Burdekin rangelands). The majority spell up to half of their property and about 10% of managers implement spelling across the entire property (as part of a grazing system e.g. cell grazing). Industry consultation during 2010 revealed there is still strong interest in pasture spelling.

Prescribed burning

The encroachment of trees and shrubs into generally open land types and the thickening of wooded land types have been shown to reduce pasture growth through competition for light, moisture, and nutrients. Within the Burdekin this has led to reductions in the safe long-term carrying capacity of many land types. As the structure of trees changes from an open woodland canopy to a more closed understory of trees and shrubs, dependent wildlife will also change (Tassicker *et al.* 2006).

Fire is a useful management tool influencing woodland structure, pasture growth, and hence animal production. Fire is also used for removing rank forage, controlling weeds, encouraging desirable pasture species, and reducing the risk of wild fires.

Fire has been demonstrated to maintain a more open woodland structure in many areas of northern Australia, yet the use of prescribed burning in the Burdekin has tended to decline after the 1970s. Reasons for this decline may include economic and social (i.e. community perception) pressures and regulation. The potential costs of burning to cash flow, dry seasons and lack of fuel, drought and the uncertainty of follow-up rain, examples of poor responses to single fires or wildfires may also be responsible for the decline in burning. As the use of fire declines, the knowledge and experience of using fire successfully in the grazing community may also decline—further reducing industry confidence in using prescribed burning as a management tool. In 2004, 39% of managers using prescribed burning for weed control, to address woodland thickening, to freshen up pastures, or for hazard reduction (Gordon *et al.* 2008).

Property development with fences and waters

Within the Burdekin catchment the average size of properties is 28,000-30,000 ha with an average of 10-15 commercial paddocks of 2000-2500 ha (not counting laneways and holding paddocks). Property size tends to be smaller and sub-viable in the higher rainfall eastern portion of the Burdekin, although there are some large holdings. Small property size was recognised as an issue in the early 1990s in the less fertile and lower rainfall Desert Uplands area in the south-western Burdekin. While some properties were large enough to sustainably carry large enough cattle herds to be viable, others were marginal or too small. Industry and community groups (such as the Desert Uplands Build-up and Development Group) have proactively promoted property size increase. The Desert Uplands Group and the Dalrymple Landcare Committee have also promoted sustainable grazing practices to address land degradation issues.

From 1994 to 2004, additional water points were installed by 83% of the 52 managers in the Dalrymple Shire who responded to a survey (Gordon *et al.* 2008) (Table 3). Of these 52 survey respondents, 69% increased their paddock number by at least one between 1994 and 2004. Of the group that increased their paddock number, 60% installed 1-4 new paddocks, 29% installed 5-8 new paddocks and 11% installed more than eight new paddocks. One manager in the survey had installed 29 new paddocks.

Landcare and associated natural resource management funding was a strong incentive to install additional watering points and paddocks (Gordon *et al.* 2008). For example, managers in 1994 who received funding installed twice as many new paddocks as those who did not.

The number of properties with laneways to aid handling of cattle has also increased. Many properties have two or three sets of cattle yards to facilitate handling and trucking of cattle. Some properties have formed roads while others are satisfied with access tracks without the need for the expensive earthworks to establish formed roads and tracks.

The survey results and observation suggest that most properties within the Burdekin have adequately developed water infrastructure. Most cattle would have to walk no more than the recommended 3 km to water.

Table 3. Changes in the number of water points (p[ercentage of graziers from sample) from 1994 to 2004 from 52 survey respondents in the Dalrymple Shire (Gordon *et al.* 2008)

Year	Watering points		
	1-10	11-20	>20
1994	33%	46%	21%
2004	15%	33%	52%

Toolbox

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Rolfe, J, Golding, T & Cowan, D 1997, *Is your pasture past it? – The glove box guide to native pasture identification in north Queensland*, State of Queensland (Department of Primary Industries).

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Chapter 5. Guidelines for grazing land management

Grazing land management is important for animal production and the financial performance of a property, the maintenance of good land condition, and avoiding declines in water quality. The most significant Reef pollutant coming from the Burdekin grazing lands is sediment (i.e. eroded soil and subsoil). Managing grazing lands for Reef protection therefore requires preventing the erosion of soil from the paddock and formation of gullies. Eroded soil will eventually be deposited again, either down-slope, somewhere within the catchment, or in the marine environment to the detriment of Reef health. Given the uncertainty of where the sediment will deposit, keeping soil on the paddock will therefore, not only conserve pasture condition, but protect rivers and streams, wetland and marine environments.

As described in previous sections, healthy ground cover (i.e. deep rooted, perennial grasses) moderates the erosive potential of rain and funnels water into the subsoil (infiltration), thereby reducing or slowing run-off and the resultant erosion. Because healthy ground cover is also required for cattle forage, maintaining and improving land condition presents a low cost option to stabilising the soil surface in order to reduce and slow run-off to reduce its erosion potential. Priority options include low or non capital-intensive solutions, such as better calculation of long- and short-term carrying capacity based on systematic photo monitoring and forage budgeting and adjusting stocking rate to match pasture conditions. Higher-cost actions, such as additional fencing, moving water-points or changing herd composition should only be considered after practical low cost options have been fully considered and implemented. In summary, long-term protection of the resource on which grazing enterprises rely is also good for Reef water quality.

In regard to reduction of soil loss, long-term economic-sustainability and environmental-sustainability are identical. In the long-term, there is therefore no trade-off between economics and environment. However, there may be a trade-off between short- and long-term economic/environmental gains. If pasture is allowed to degrade because of short-term economic gains, both environmental and long-term economic viability are likely to suffer.

Aims for land management

These guidelines are designed to assist producers meet their goals by addressing common aims of managers in the Burdekin grazing lands (refer to Table 4). These common aims are:

1. maintaining land in good (A and B) land condition
2. improving land in poor (C) land condition
3. stabilising and recovering land in very poor (D) land condition
4. managing frontage country and wetlands
5. reducing grazing pressure in selectively-grazed areas
6. locating water points to even out grazing
7. minimising erosion when locating infrastructure
8. minimising woody plant problems
9. managing chemicals and fertilisers

Table 4. Key land management aims for the Burdekin grazing lands.

Aim	Situation	Factors to consider (refer to Chapters 6 to 14)
1. Maintaining land in good (A and B) land condition	• Pastures are mainly in A or B land condition. • 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. • There may be a few overgrazed patches with low ground cover and the presence of less desirable species (C land condition). • Continued overgrazing of these C condition patches increases their size and frequency. If continued over a period of years, the average land condition goes from A-B to C.	• Indicates a history of good grazing management. • Temporal variability in pasture growth rates between years, during years and on different parts of the property leads to variation in feed supply. • Compounded by limited flexibility to vary cattle numbers within and between years; breeder enterprises have the least flexibility of all.
2. Improving land in poor (C) land condition	• Most of the paddock or preferred land type/s is in C condition. • There are still some 3P grasses but they are widely spaced and may be small with low vigour. • Persistent patch grazing is occurring. • Ground cover is highly seasonal and generally poor towards the end of the dry season with substantial loss of water through runoff. • There is a high proportion of annual grasses, forbs or undesirable species. • Highly nutritious feed may be available for short periods after rain, but feed shortages can develop quickly in dry periods.	• Drought. • Chronic and sustained excessive grazing pressure. • Selective use of land type or portion of paddock. • Can be exacerbated by intense wildfires.
3. Stabilising and recovering land in very poor (D) land condition	• Significant soil erosion. • Substantial weed infestation. • Very low to no ground cover. • Very few or no 3P grasses. • Often approaching desertification in appearance.	• Chronic and continued overgrazing. • Loss of 3P grasses and ground cover. • Invasion of aggressive weeds.
4. Managing frontage country and wetlands currently	• Bare soils. • Gullies. • Poor vegetation including weeds. • Eroding streambanks. • Pugging. • Highly turbid water and/or algal blooms.	• Concentration of stock in these preferred areas. • Selective grazing. • Weed invasion. • Vegetation clearing or death through intense fires. • Pigs.
5. Reducing grazing pressure in selectively-grazed areas	• Heavily grazed areas and patches contrasting with other areas which are ungrazed and where the pasture has become rank. • Patches and ungrazed areas vary in species composition, morphology, structure and availability of forage.	• Animals graze more at locations with abundant quantities of preferred forages. • Animals avoid low quality forage, select high quality patches and regraze these preferred patches. • Past grazing has modified the plants present and their characteristics. • Current grazing determines available forage. • Distance to water is an important determinant of grazing distribution. • Patches may reflect different grazing use in the past and growth responses to dung and urine and burns.
6. Locating water points to even out grazing	• Significant areas of the paddock receive little or no grazing pressure.	• Inadequate number and/or location of water points in relation to paddock size. • Avoidance of land types with less palatable pastures or limited accessibility.
7. Minimising erosion when locating infrastructure e.g. fences	• New forms or increased rates of soil erosion.	• Areas of reduced ground cover. • Altered water flows. • Problem soils. • Poor placement of infrastructure. • Gully formation.
8. Minimising woody plant problems	• Increased density of shrubs and trees, particularly on productive soil types. • Reduced pasture growth when woody vegetation is thick. • Encroachment into open land types.	• Sequences of very wet years. • Reduced competition from grasses due to heavy grazing. • Reduced frequency and/or intensity of effective fires.
9. Managing chemicals – herbicides and fertilisers	• Excess vegetation growth in water ways e.g. algae. • Death of aquatic animals.	• Herbicides, fertilisers and feed supplements carried in run-off to waterways. • Chemicals applied according to label and stored correctly. • Impact on the health of the Great Barrier Reef. • Pollution of waterways leading to excess of vegetation e.g. algae from fertiliser and death of aquatic animals from pesticides.

The emphasis in this guide is on eucalypt woodlands but much of the material is also relevant to sown pastures on brigalow-gidgee scrubs e.g. the importance of matching stocking rates to long-term carrying capacity. (Feedlot operations, fodder crops, and intensive pastures are not covered).

Principles and guidelines

In the NGS project the results of past research were synthesised to develop a set of principles and guidelines for managing stocking rates, wet season spelling, using fire to manage woody weeds, and using fences and water points for the better use of grazing lands in northern Australia (McIvor *et al*. 2010). The principles and guidelines are presented in Table 5 and have been drawn on in developing the management options presented in later chapters.

Table 5. Principles and guidelines for managing grazing lands in northern Australia developed as part of the NGS project. (from McIvor *et al*. 2010)

Principle 1. Managing stocking rates is vital to meeting animal production and land condition goals
Guideline 1.1. Adjust stocking rates to match long term carrying capacity benchmarks for the land type. Plan for the average paddock stocking rate to match its estimated long-term carrying capacity, as operating at or around the long-term carrying capacity will help maintain land in good land condition. The extent to which stocking rates can exceed the long-term carrying capacity without reducing economic returns and/or reducing land condition is unclear.
Guideline 1.2. Regularly assess the need to adjust stocking rates in relation to current and anticipated feed supply and feed quality. Some variation in stocking rates over time is required to manage periods of below-average pasture growth. Capacity to vary numbers over time also provides opportunities to take advantage of periods of above-average pasture growth. The degree of variation that is most beneficial and achievable, for different production systems is not clear.
Guideline 1.3. Management factors and issues other than forage supply also determine the need to vary livestock numbers. The adjustment of stocking rates over time should also consider changes and trends in land condition, grazing pressure from other herbivores, and economic risk.
Principle 2. Spell pastures to maintain them in good land condition or to restore them from poor land condition to improve pasture productivity
Guideline 2.1. Spell pastures during the growing season. As a rule of thumb commence the spell period after 40–50 mm of rain or sufficient to initiate pasture growth at the beginning of the growing season. If it is difficult to access or muster country after rain then spelling should commence at the last mustering round before the wet season starts.
Guideline 2.2. Spell pastures for the whole growing season. Spelling pastures for the whole growing season is likely to provide the most reliable benefit but most of this benefit appears to accrue from spelling during the first half of the growing season.
Guideline 2.3. Pastures need two growing season spells to improve by one land condition class. Pastures in B land condition need spelling for one or two growing seasons to improve to A land condition. Pastures in C land condition will need longer so plan on taking four good growing seasons to recover to A land condition. Where growing conditions are poor, more spelling periods will be required.
Principle 3. Devise and apply fire regimes that enhance grazing land condition and animal productivity while minimising undesirable impacts
Guideline 3.1. Use fire to manage woody species. It may not be necessary to kill target species — topkill can be sufficient to alter the structure of woody populations. Fires of moderate to high intensity are most likely to be effective in regulating the density and yield of woody plants. Fuel loads are a critical issue — to reduce populations/yield of woody species, a minimum fuel load to carry an effective burn of 2000 kg/ha is suggested.
Guideline 3.2. Use fire to change the composition of the pasture layer by killing plants, influencing recruitment, or altering grazing preferences.
Guideline 3.3. Use fire to change grazing patterns by temporarily improving the attractiveness of previously ungrazed areas and providing spelling to previously grazed areas.
Principle 4. Use fences (paddocks) and water points to manage timing and intensity of grazing
Guideline 4.1. Smaller paddocks and additional water points can achieve more effective use of pastures i.e. reduce the proportion of the paddock that experiences little grazing. In the more extensive grazing areas of the Burdekin producers should aim for: • paddocks of 3000–4000 ha with two water points and • a maximum distance to water of about 3-4 km to strike a balance between improving grazing distribution and the cost of development. For the more productive regions in the eastern part of northern Australia (including parts of the Burdekin rangelands), it is likely that paddocks of 2000 ha with two water points are sufficient from the perspective of optimising grazing distribution. Smaller paddocks may still benefit from sub-division where cattle show a strong preference for land types within a paddock. To minimise the development of large sacrifice areas around water points the number of head per water point should be limited to no more than 300 head per water point.
Guideline 4.2. Smaller paddocks and additional water points do not overcome uneven utilisation by cattle at the plant community or patch scales. Other methods (e.g. fire, careful selection of water point locations) are needed to improve evenness of utilisation at these scales.
Guideline 4.3. Property development can generate significant increases in livestock production only where it results in more effective use of the pasture (increasing carrying capacity) as substantial improvements in **individual** animal production are unlikely to be achieved by this process. If an undeveloped paddock is already operating at its long-term carrying capacity, paddock development may improve the sustainability of grazing through more even grazing.
Guideline 4.4. Fencing and water points can be used to help protect preferred land types and sensitive areas from overgrazing. Fencing to separate markedly different land types is an important strategy for controlling grazing pressure on preferred land types and to achieve more effective use of all pasture resources on a property. It can be a practical option in some situations and should be considered where property development is planned.

Targeting management to reduce soil loss

The most efficient strategy for reducing the risk of soil being lost from grazing properties and entering waterways is to use stocking rates linked to long term carrying capacity that maintain adequate ground cover and the vigour of preferred perennial pastures. Wet season spelling can play an important role in maintaining preferred perennials and grazing land condition.

The most cost-effective areas to target for improving land condition and reducing erosion are those that are currently in C condition. Rehabilitation of areas in D condition on low productivity land types is an expensive approach to sediment reduction and may not be economic for the landholder to undertake without subsidies e.g. to build fences. For D condition land to recover, some form of mechanical intervention, like ripping, is often needed.

Management aims and management options

In the next nine chapters possible management options to achieve the management aims listed above are described. The relationships between aims and management options are summarised in Table 6 and serve as the structure for the chapters. The management options are divided into two groups— most cost effective options that can be implemented as part of property management without major investment and those that require investment.

Table 6. Summary of management options matched to management aims.

	Management option	Management aim: Maintaining land in good (A and B) land condition	Improving land in poor (C) and condition	Stabilising and recovering land in very poor (D) land condition	Managing frontage country and wetlands	Reducing grazing pressure in selectively-grazed areas	Locating water points to even out grazing	Minimising erosion when locating infrastructure	Minimising woody plant problems	Managing chemicals and fertilisers
Most cost effective	**Stocking rate**									
	• Match stocking rate to long-term carrying capacity	✓✓							±±	
	• Use forage budgeting to adjust stocking rate to seasonal conditions	✓✓	✓✓							
	• Reduce stocking rate to match land condition		✓✓							
	• Control cattle grazing pressure with moderate stocking rates and wet season pasture spelling				✓✓					
	Spelling									
	• Implement wet season pasture spelling	±±	✓✓			✓✓			±±	
	Burning									
	• Implement prescribed burning	±±	±±						✓✓	
	Record keeping									
	• Record use of chemicals and conform with regulations for their use									✓✓
	• Record fertiliser use and minimise risk of fertiliser loss									✓✓
Investment required	**Erosion control**									
	• Increase water infiltration on bare, scalded area			✓						
	• Starve gullies of water			✓						
	Weed and pest control									
	• Control and manage woody weeds			✓						
	• Regular weed and pest control				✓					
	• Integrated weed management								±	
	Infrastructure – water points and feed stations									
	• Locate water points and supplementary feeding sites away from preferred areas					±				
	• Install more water points in large paddocks						✓			
	• Control cattle access with fencing and off-stream water points				✓					
	Infrastructure - fencing									
	• Fence to control grazing and reduce stocking rate			✓						
	• Fence off selectively-grazed areas and manage separately					✓				
	• Locate fences on contour lines or ridge lines							✓		
	• Optimise paddock size						✓			
	Infrastructure – roads and tracks									
	• Locate and construct roads and tracks to avoid problem soils and concentrating water							✓		

✓✓ highly recommended ±± complementary ✓ recommended but requiring investment ± complementary but requiring investment

Key tools for decision making

Two tools that are useful in achieving a number of the management aims covered in the following chapters are monitoring and forage budgeting.

Monitoring and record keeping

Ongoing monitoring of land condition for detecting changes in pasture condition, ground cover, erosion areas, weeds etc is important for adjusting management in response to changes in land condition. Unfortunately, memories are unreliable guides to the past and changes in land condition can be gradual and go undetected. A systematic recording scheme provides a record of past conditions and may enable changes to be detected early so that it is possible to alter management prevent major changes or declines. Keeping records of cattle numbers (in animal equivalents, AEs) and land condition in each paddock throughout the year and recording any changes will help to determine suitable stocking rates.

Stocktake (Alexander and Paton, 2009) has been developed for assessing pastures and estimating carrying capacity and potential to meet animal demand. Stocktake uses photo-points and field assessments to assess grazing land condition in ABCD classes. The field assessment involves classifying paddocks into land types (and possible management areas) and locating photo-points in each, with up to four separate visual assessments.

Photo monitoring

Photo monitoring is a credible method of demonstrating change, from year to year, in the landscape. It is an industry and government endorsed methodology and forms a key monitoring component of the Grazing Land Management program (Department of Agriculture, Fisheries and Forestry) as well as under the Delbessie Agreement (Rural Leasehold Land Strategy).

Consistency in the photos is a key to recording changes in land condition. It is therefore important that the photos taken are:

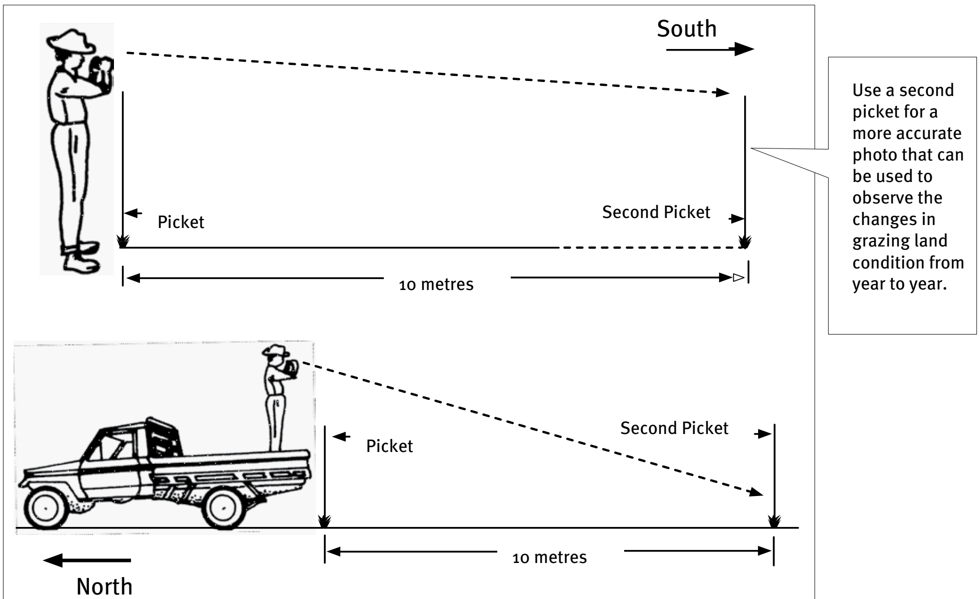
- from the same point in the landscape
- from the same direction
- featuring the same land marks, e.g. a major tree or a shed in the distance.

The following steps are important:

Step 1. Choose a suitable site and mark the site using steel pickets with clearly visible markers so they are easy to locate. Two pickets 10 metres apart help to line up the photograph.

Step 2. To take a photo stand at the picket, face south and take a photograph of the site showing mostly landscape (refer to diagram below).

The best time to take your photograph is between 9 am and 4 pm. Make sure the photograph reflects the same view of the landscape each time it is taken by including a land mark in your photograph. Writing the site



Adapted from Alexander, J. and Paton, C. (2009)

name, GPS point, and date on a chalk board or white board that is included in the photo provides a permanent record of the site.

Monitoring land condition is part of the leasehold conditions for grazing land in Queensland. A booklet on 'Guidelines for determining lease land condition' (refer to Chapter 5 Toolbox, DERM 2009) has been produced that sets out attributes of land condition (pasture, soil, biodiversity, declared pests, salinity, riparian vegetation and natural water resources) along with 37 indicators.

Photo standards are useful aids when assessing land condition and a collection for the Burdekin grazing lands has been published (Karfs *et al*. 2009b).

Forage budgeting

Forage budgeting is a useful tool to estimate the feed requirements of cattle and to avoid under- or over -use of pastures. Forage budgeting can be done for any period but is most suitable at the end of the wet season before the dry season starts when little pasture growth is expected and animals must survive on existing pasture until the next growing season. It can be used during the growing season but if this is done then some estimate must be made of likely pasture growth during the budgeting period and this is difficult to do. Note that if other herbivores are competing with cattle for forage, they need to be taken into account in forage budgets.

Developing a forage budget involves estimating:

- how much feed is available for animals over the planning period
- how much feed the animals require over the same period
- comparing these two values.

This is illustrated below for a 500 ha paddock running 200 wet cows.

Estimating feed available involves:

Step 1. Determine the area of the paddock. (Accurately estimating the area of the paddock is essential for determining the amount of feed available).

Step 2. Assess total dry matter in the paddock at the end of the growing season (approximately April / May). Experienced operators may use photo standards to assess relative yields but inexperienced operators should cut, dry and weigh some pasture to 'get their eye in'. Even experienced operators are well advised to cut some quadrats (0.5 x 0.5 m square) of pasture to re-tune their assessments. This value gives the total amount of feed available (for example 3000 kg/ha).

Step 3. Estimating the proportion of the total amount that is unpalatable to animals and subtracting this from the total amount. (if 20% is considered to be unpalatable then 2400 kg/ha can be consumed).

Step 4. Making allowance for residual pasture (800–1000 kg/ha and 40-70% ground cover) to remain at the end of the period to protect the soil surface, provide organic material for other organisms and to incorporate in the soil (planning for a residual of 1000 kg/ha means 1400 kg/ha can be eaten).

Step 5. Allowing for pasture not available for cattle. Dry matter may be detached from the plants (e.g. by wind), trampled by animals or consumed by other herbivores making it unavailable for cattle to eat (if we allow for say 40% to be in this category then the feed available for the cattle to eat is 840 kg/ha).

Step 6. Calculate the total feed available in the paddock. In this example, total feed available is:

500 (ha) x 840 (kg/ha) = 420,000 kg

Available forage (kg/ha) = Total dry matter yield – (unpalatable dry matter + residual pasture + loss of pasture)

Estimation step	Example estimation (kg/ha)	Remaining forage (kg/ha)
2. Total dry matter yield	3000	3000
3. Unpalatable dry matter (20% of total)	600	2400
4. Residual pasture	1000	1400
5. Pasture loss (40% of remaining)	560	840

Estimating the feed requirements of animals involves determining:

Step 1. How many animals and what type of animals are being planned for?

Different classes of stock will eat different amounts of feed. This can be accounted for by bringing all stock back to numbers of Adult Equivalents (AEs).

For example a 450 kg steer or a 450 kg dry cow is equal to 1 AE and it will eat about 10 kg of pasture dry matter per day on average over a year. A wet cow is about 1.35 AEs on average over a year and so will eat about 13.5 kg of pasture dry matter per day.

Step 2. How long is the planning period?

Using the number of days in the planning period, the number of AEs and allowing for 10 kg/head/day for each AE, we can estimate the feed requirement. For example, if we have 200 wet cows (equal to 270 AEs) and a planning period of 180 days then the feed requirement is:

270 (AEs) x 10 (kg/AE) x 180 (days) = 486,000 kg

We can now determine whether the paddock will have sufficient pasture for stock to last until the end of the planning period. In this example the available feed is 420,000 kg and the animal demand is 486,000 kg so there is not sufficient feed for these animals for the whole period and the number of animals will need to be reduced in this paddock.

A forage budget might indicate there is ample feed for existing stock and enough to bring in more cattle if the enterprise allows e.g. growing store cattle for short periods (up to six months) for sale to feedlots, or taking on agistment stock. Keep in mind that once the amount of feed eaten as a proportion of palatable pasture exceeds 30%, extra supplements may be required to simply maintain the liveweight of cattle.

There are spreadsheets that make these calculations easier including one in the Stocktake database that allows for more detailed control of intakes at different times of the year if that is the operator's preference. Another useful course that uses forage budgets as part of the assessment process is the EDGE Nutrition workshop.

Toolbox

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For current DAFF workshops please refer to the Future Beef website ‹www.futurebeef.com.au›.

Chapter 6. Maintaining paddocks in good (A and B) land condition

Considerable areas of the grazing lands in the Burdekin are in good land condition (generally A-B) where 3P grasses dominate pasture yields, woodlands are generally stable, weeds are minimal and there is little to no erosion. Figure 2 shows the relationships between situations where this occurs, an assessment of causes, appropriate management responses and the management options available to achieve this aim. The remainder of the chapter then covers these issues in detail.

Maintaining land in generally good (A and B) land condition

Situation:

Pastures are in generally good (A and B) condition with ample feed in good seasons, adequate feed in average seasons and possible inadequate feed in poor seasons. There may be a few overgrazed (C) condition patches

Factors to consider:

Effective short- and long-term management to avoid mismatches in pasture supply and animal demand due to variation in pasture growth

Management response:

Improve stocking rate management, complemented by wet season spelling and use of prescribed fire if some decline in land condition e.g. patchy overgrazing

Management option:

Match stocking rate to long-term carrying capacity

Management option:

Use forage budgeting to adjust stocking rate to seasonal conditions

Complementary management option:

Implement wet season spelling

Complementary management option:

Implement prescribed burning

Figure 2. Diagram showing how this chapter on maintaining paddocks in good (A and B) land condition is structured.

Situation

Pastures are generally in A-B land condition but may have some overgrazed patches with low ground cover and may have some less desirable species (C land condition patches).

These 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.

Grass response to good growing conditions can also be adequate, because of the good land condition. However when extended dry conditions are experienced, the land condition and animal production will deteriorate if overgrazing occurs.

Factors to consider

Land in predominantly good land condition implies that the historical management has been able to maintain or improve land condition. These areas have typically had a history of good management, with grazing pressure rarely exceeding pasture availability and are likely to be on the more resilient land types. They also include areas that have not been actively grazed, such as areas far away from water or on defence training areas.

Maintaining such good land stewardship is not always easy, especially with rising costs of production, declining terms of trade, the severe drought of the early 2000s, or in areas where woody plants are invading or increasing. Matching feed supply with animal demand when pasture growth rates vary considerably from year to year – or as tree seedlings grow and impact on pasture production – is not always simple. If stocking rates are allowed to become generally higher than long-term carrying capacity, mismatches in feed supply and demand will occur frequently and land condition will decline. Cattle breeding enterprises often have limited flexibility to vary cattle numbers within and between years.

Any overgrazing is likely to lead to C land condition patches increasing in size and frequency and if continued for a longer period it is likely that land condition within paddocks will decline overall. Operating in this manner can often be profitable for a number of years, until extended dry conditions are experienced. Animal production per hectare can be maximised, even though per head production is not. The resilience and stability of land in good condition can lead to 3P grass density being maintained, giving the appearance that the land resource is not suffering.

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

Goal: to optimally use the feed for animal production, while at the same time maintaining land condition.

The major challenge is to match animal demand and feed supply. A continuation of historical management of land in A/B land condition should continue to maintain good land condition and there may be no need for any changes. However, where any increase in stocking rate or infrastructure development is planned, the following considerations apply. Moreover, even pastures in good condition can be degraded if management in not adjusted in response to poor climatic conditions for pasture growth.

Although changes in pasture growing conditions are a major cause of mismatches between feed supply and demand, they are largely outside the control of managers and the most important management response is to adjust stocking rate. High stocking rates increase pasture utilisation. In good years this can increase animal production per hectare and profitability, but in poor years high stocking rates can give poor animal production, high costs can be incurred and pastures can degrade.

The amount of feed grown each year can vary widely due to climate variability so the appropriate number of animals to utilise the feed also varies widely. In theory, it would be desirable to change animal numbers each year so that the feed demand by animals matches the feed supply from the pasture. In this way, overgrazing and subsequent pasture deterioration during periods when pasture growth is low are avoided and animal production increases in years with high pasture growth. However, this is not simple as the feed supply is not known in advance and there are limits to how much and how often animal numbers can be altered — particularly in a breeding enterprise.

There are two broad approaches. The first approach is to stock at a relatively low level so that the level of pasture utilisation is not excessive in any year (or at least most years). This approach avoids overgrazing in poor years but forgoes the extra animal production that could be achieved in good years and hence may incur a financial penalty. The second approach is to adjust animal numbers so that animal demand does not exceed current and/or anticipated future feed supply. This should minimise periods of overgrazing and feed deficit while making good use of feed in above-average years. This can result in higher overall utilisation of feed. However, it increases the risk of overgrazing if animal numbers are not reduced quickly enough when pasture supply is low. Lack of knowledge on what seasonal conditions will prevail means there is no guarantee of increased animal productivity by increasing stocking rates during good years. There are also risks. Higher animal numbers with insufficient quantity or quality of feed can result in forced sales, extra supplement costs or lost animal condition.

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

Management option: Match stocking rate to long-term carrying capacity

To maintain land in good condition, it is important not to increase grazing pressure above the long-term carrying capacity by adding too many stock to paddocks. A risk-averse approach has generally proven to be the most successful long term approach to managing stocking rates (Buxton and Stafford Smith 1996, Landsberg *et al*. 1997, O'Reagain *et al*. 2009). Stocking at close to the long-term carrying capacity results in average annual pasture utilisation rates that are appropriate for the land type. For example, basalt land types may sustain a safe utilisation level of 30%, while the rate for lancewood-bendee is only 10% (Whish 2010). Stocking to the long-term carrying capacity of the land in most years is generally the most profitable in the medium to long term and the least risky (economically and ecologically) approach to managing stocking rates. The focus should be on maximising profit per hectare in the long term. Maximising production per hectare is not necessarily the way to maximise overall profit.

High stocking rates in excess of the long-term carrying capacity may be more profitable in the short term but are less profitable over the longer term because of the effect of drought years and decline in land condition and productivity. Maintaining high stocking rates during drought causes land degradation that can reduce production for years after—or increase subsequent yearly variability in production. High stocking rates (especially on poor condition land or in poor seasons) can mean cattle will be subject to weight-for-age penalties at market or increased supplement costs—both of which can reduce profit. On the other hand, consistently low stocking rates may not be productive enough to be profitable.

The safe pasture utilisation rate concept and historical rainfall and pasture growth data for different land types can be used to develop an understanding of the long-term carrying capacity of the land [refer to the EDGE*network* Grazing Land Management (GLM) Manual by Chilcott *et al*. 2000]. Safe pasture utilisation rates tend to be lower in less productive regions (e.g. lower annual rainfall, shorter growing season, less fertile soils) and where annual rainfall is more variable. A more conservative approach to setting stocking rates is required in such regions.

Evidence

There have been many experiments over more than 50 years examining stocking rate or utilisation responses. Most of these have been in Queensland (both east and west), with some in the NT and WA (refer to Johnston *et al*. 1996, Hall *et al*. 1998, Ash and McIvor 1998, Ash *et al*. 2001, Hunt 2008). As a general rule they show a decline in pasture condition as utilisation rates exceed approximately 30%.

Expert knowledge has been used to develop recommended safe utilisation rates for land types in northern Australia.

There is a large body of international and Australian literature showing animal production per head declines - and animal production per unit area initially increases and then declines as stocking rate is increased. Most studies with intensively managed sown pastures have shown a linear decline in animal production per head with an increase in stocking rate (Jones and Sandland 1974). A similar situation applies in the rangelands although Ash and Stafford Smith (1996) have shown that animal production in rangelands is less sensitive to changes in stocking rate due to the much greater spatial and temporal variability of rangelands.

The Wambiana trial near Charters Towers (O'Reagain *et al.* 2009) showed that constant moderate stocking (approximately 8-10 ha/AE; 25% utilisation) gave good financial returns and maintained pasture condition in the long-term. Constant heavy stocking (approximately 5 ha/AE; 50% utilisation) gave good returns during wet years but not when poor seasons were experienced; it also led to poor pasture condition. The density of 3P tussock grasses and contribution of 3Ps to total yield and basal cover was greater in the moderate stocking treatment than the heavily stocked treatment. Pasture condition was maintained under moderate stocking despite years with below average rainfall, but declined under heavy stocking. Importantly, Ash and McIvor (1998) demonstrated that medium to high pasture utilisation (30-45%) during the growing season can suppress plant growth in subsequent seasons.

High stocking rates also reduce ground cover, increasing run-off and soil loss. Measurements at Cardigan showed soil movement in native woodlands stocked at 1 AE/3 ha was nearly three times that in woodlands stocked at 1 AE/15 ha (McIvor, Williams *et al.* 1995). Given that many of the nutrients required for plant growth are concentrated in the top few centimetres of surface soil, the removal of soil can reduce pasture productivity and limit the recruitment of 3P grasses. Maintaining high levels of ground cover is essential to promoting water infiltration into the soil, minimising soil and nutrient loss, thus protecting the productive potential of the land and maintaining river water quality (Post *et al.* 2006; O'Reagain *et al.* 2007). The critical levels of ground cover vary between rangeland types and depend on factors such as soil type, slope, amount and intensity of rainfall and pasture vegetation type.

Other grazing experiments in Central Queensland (Gemfields and Calliope districts) demonstrated similar declines in 3P grasses, ground cover and increases in erosion.

Implementation

- Calculate long-term carrying capacity based on paddock size, land type and land condition using a method such as Stocktake.
- Allow for grazing pressure from feral and native herbivores that may be present when determining stocking rates.
- Also discount the stocking rate taking into account the area of a paddock unlikely to be grazed by cattle because it is too far from drinking water
- After these discounts, calculate the long-term carrying capacity based on the average pasture growth with deductions for tree competition and lost productivity for areas of poor land condition.
- GLM provides training and relevant information to perform these calculations.

Considerations and caveats

Long-term carrying capacity is a benchmark value. The actual stocking rate will rarely match this long-term value as adjustments are made for seasonal conditions, especially drought.

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

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

Management option: Use forage budgeting to adjust stocking rate to seasonal conditions

Adjustment of stocking rate around the long-term carrying capacity to account for seasonal conditions is generally necessary to ensure good pasture condition and to improve profits in northern Australia. Within the Burdekin grazing lands, industry consultation indicates that current practice is to adjust stock numbers by a maximum of 20% from year to year e.g. total numbers may be reduced by 20% in response to below average rainfall and reduced pasture yields. This reduction is not likely to occur evenly across all classes of cattle. Most properties are unlikely to vary stock numbers above or below 40% of their estimated property carrying capacity.

Forage budgeting is a tool for adjusting stocking rates based on acceptable levels of pasture utilisation, pasture yield and the intake requirements of cattle. Forage budgets are usually conducted at the end of the summer pasture growing season when the amount of forage available for the coming months can be estimated. They are typically used for grazing periods from 30 to 240 days and are re-assessed once the next wet season commences. These budgets should be tempered with managers' experience of the numbers of cattle that paddocks can safely carry but provide a pasture-based rather than animal-based assessment of how many stock can safely be carried. Longer feed budgeting periods should be used where the long-term season outlook is poor (i.e. strongly negative SOI). In this instance a forage budget to the end of January rather than to December is safer.

Forage budgets allow stocking rates to be increased above the long-term carrying capacity in good seasons to take advantage of above average pasture growth with a low risk of harming the pasture. They can also be used to promptly reduce stocking rates early, before pasture availability and seasonal conditions decline. Reducing stocking rates quickly is important as major declines in land condition – that can persist for decades– generally result from high stocking rates during periods of low rainfall and low pasture availability.

Evidence

Stocking above the safe utilisation level leads to a decline in land condition - forage budgeting is a tool to avoid this. A number of grazing experiments have been conducted over the past 40 years examining the effects of utilisation rate on pasture performance in a wide range of land types and climates. These include Ecograze (desert bluegrass and spear grass), Toorak (Mitchell grass), Burenda (Mitchell grass), Arabella (mulga) and the Aristida-Bothriochloa project at Injune and Rubyvale (wiregrass and blue grass based pastures). While the method of determining utilisation rate varied between studies, these experiments consistently show declines in both animal production per head and pasture condition as utilisation rate increases.

The Aristida-Bothriochloa project showed that increasing utilisation of pastures reduced liveweight gain per head but liveweight gain per hectare increased. However, there was only a slight increase in production per hectare going from a moderate grazing pressure (50% use of end of growing season standover pasture) to heavy grazing pressure (75% use of standover pasture). Profitability was greatest at the moderate utilisation level but this is somewhat marred by erosion and soil losses being considerably higher than at lower grazing pressure (25% use of standover pasture).

Set stocking and a strategy where stocking rate was varied annually in response to pasture availability was compared experimentally in the Wambiana grazing trial (O'Reagain *et al.* 2009). In the variable stocking rate treatment animal numbers were changed each year at the end of the growing season. The variable stocking regime gave no net advantage due mainly to problems (both financial and declining land condition) in the transition from good to poor years i.e. adjusting cattle numbers annually may not provide a rapid enough response to manage for drought conditions.

Implementation

- Do a forage budget (refer to Chapter 5) at the end of the wet season (March/April) to determine the number of animals that can be grazed through the coming dry season, using tools such as Stocktake. Forage budgets should be reviewed regularly through the year taking into consideration patterns of grazing distribution within paddocks. Musters provide a good opportunity to review the feed budget and to adjust stocking rates based on pasture availability.
- The condition of 3P grass tussocks (such as the amount of residual yield or stubble height) are important indicators of future plant survival and pasture productivity.
- Reducing stocking rates late in the wet season may allow seed production by 3P grasses.
- Where they are proven to reliable, seasonal forecasts can be combined with the estimates of standing forage yield at the end of the wet season. The Southern Oscillation Index (SOI) is generally reliable in the Charters Towers district. A strongly or consistently negative SOI usually indicates El Nino drought events are on the horizon and having a plan for de-stocking in place is advisable — especially being ready for a delayed start to the next wet season. Extending the forage budget period into the late summer will also assist cattle and pastures in arriving at the next wet season in reasonable condition in El Nino years.
- Stock numbers should be reduced in poor years, especially after poor wet seasons because of the sensitivity of 3P grasses to grazing at this time. A sound approach is to progressively sell non-productive stock to allow more productive stock to do better. Plans for a progressive reduction in stocking rates during deteriorating seasonal conditions should be developed to avoid crisis management. In general, de-stocking quickly coupled with a conservative pace of re-stocking helps to maintain land condition.

Considerations and caveats

It is wise to set an upper stocking rate limit even for very good seasons to avoid excessive pasture utilisation rates. This upper limit should not exceed about 50% pasture utilisation in the more productive land types. In the less productive land types, this upper limit should not exceed 20% pasture utilisation.

While reducing stock numbers before the wet season can help protect pasture condition, there are significant disadvantages trying to sell stock at the end of the dry season. Animals are often not in good condition and demand is often poor resulting in low prices.

Adjusting cattle numbers to suit the quantity of feed on hand, anticipated pasture growth and seasonal outlook (SOI) is best done at normal mustering times. This reduces the expense of extra musters to solely reduce numbers.

Good growing seasons with an ample supply of feed may provide an opportunity to spell pastures to maintain land condition and/or to use fire to manage woody plant populations (refer to Chapter 13). Spelling pastures allows the health and vigour of 3P grasses to improve as root systems and crown cover increase. The extra body of feed ensures a safety net for maintenance of ground cover should the next wet season be poor.

Forage budgeting at the beginning of the wet season – compared with at the end – provides a guide only. There is considerable uncertainty associated with wet season pasture growth based on seasonal rainfall forecasts.

Bio-economic modelling generally demonstrated advantages in 3P grass composition, live-weight gains and economics in using a flexible stocking rate strategy across northern Australia. These advantages were not confirmed for the Burdekin where a fixed stocking strategy, based on 5 ha/AE for the goldfields land type was used.

A forage budget should be done at the end of the growing season and once or twice over the grazing period to check that things are on track. This type of forage budget allows managers to make stocking rate and selling decisions early in the dry season, or even during the latter part of summer, rather than being reactive and forced to make a decision in crisis situations. It should be done for the whole property at this time of year irrespective of grazing system.

Those using rotational grazing systems tend to use forage budgets or similar tools on a much more frequent basis to determine how long to graze each paddock or sub-paddock in a cell or paddock rotation. This is a useful process but an overall paddock and property forage budget is still necessary at the end of the growing season to forecast feed deficits over the drier part of the year.

Forage budgets can assist in planning for fire, by factoring in a sufficient end of season residual fuel load to carry a suitable burn, where woody plant thickening or encroachment is a problem, or in areas where undesirable grasses such as wiregrass are dominating the pasture.

Complementary management option: Implement wet season pasture spelling

Spelling pastures will both increase the amount of pasture grown and reduce the amount consumed over the wet season. This can increase the total feed supply or defer when it is consumed. Pasture spelling also has a role to play in maintaining and restoring pasture condition. Patches that have been overgrazed are able to recover which will assist with evenness of grazing. 3P grasses also obtain a competitive advantage over the less desirable and less productive plants such as wiregrass and Parthenium.

Evidence

While there has been considerable research on using pasture spelling to improve land condition (refer to Chapter 7), there has been little study of the effects of pasture spelling on land in good condition. One of the few studies was the Ecograze project at Charters Towers where spelling paddocks in the early growing season each year for eight weeks combined with 50% utilisation gave similar pasture performance to 25% utilisation without a pasture spell (Ash *et al*. 2001; Ash *et al*. 2011). Both these treatments maintained land in good condition.

Pasture spelling during the early growing season avoids the grazing of regrowing 3P grasses when they are most sensitive to defoliation. By allowing selectively-grazing patches to grow without continual defoliation, they become more like the remainder of the pasture and animals are less likely to return to these patches (especially if spelling is combined with fire — refer to Chapter 13).

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).

Implementation

- Stock should be removed from the paddock to be spelled soon after the first heavy wet season rainfall and kept out of the paddock until after the 3P grasses flower.
- The most practical approach may be to remove stock in the late dry season muster and return them after the early dry season muster.
- Where a number of paddocks have similar long-term carrying capacity, spelling can be implemented by spreading the herd from the spelled paddock over the remaining paddocks. For example, with a four herd, five paddock system, each paddock would get a spell every five years if seasonal conditions permit.

Considerations and caveats

Where areas of preferred land types are large enough, adopt wet season spelling and stock at appropriate levels after the spell.

Implement a rotational wet season spelling program to improve the management of preferred land types and riparian areas.

In reality, spelling management will entail logistical challenges and there is little if any evidence to guide the implementation of spelling actions. Although spelling for the whole wet season is expected to give the best results, local information in the Burdekin suggests that a short (5-6 week) wet season spell (either early or late or both) can maintain land condition. A full wet season spell may not be needed and could forego useful grazing.

Patches develop under continuous grazing even with light stocking rates in the Burdekin. Wet season spelling can reduce this patchiness and may be most effective when used in conjunction with burning.

Complementary management option: Implement prescribed burning

Fire can be used as a management tool to prevent the development of patch grazing or reduce woody plant problems. While the major role of prescribed burning is in suppressing woody plants (refer to Chapter 13), fire can be used to influence where animals graze by encouraging them onto more palatable areas regrowing following fire.

Evidence

There is both experimental evidence (e.g. Andrew 1986b) and practical experience that animals prefer burnt areas that are regrowing to unburnt areas. For example one grazier at the Willows in the Fitzroy has successfully evened out grazing distribution in silver-leaved and narrow-leaved ironbark country on hills and ranges by burning on the top of ridges to attract cattle to pastures that were rank and ungrazed before being burnt.

Hassall (1976) described a system used on basalt country with predominantly kangaroo grass pastures in the Upper Burdekin. Half of a paddock was burnt in alternate years. The animals preferentially grazed the burnt half in the early growing season and grew rapidly on the young green pasture. The spelling of the pasture was ungrazed and grew to maturity ready for burning at the end of the year. By April the grazed area was 12-14 cm tall and animals were removed to another paddock which had also been similarly burned. They grazed there for three months before returning to the original paddock for the remainder of the year after which the paddock was again burned and cycle repeated.

A study at Swan's Lagoon in the lower Burdekin explored whether early wet season burning increased animal production (McLennan *et al*. 1986). It measured pasture availability and steer live-weight gains in pastures dominated by black spear grass, comparing five burning treatments grazed at 3 ha/beast. Yields of plots burnt annually in the early wet season were 8% lower than those of unburnt plots. Live-weight gains were 'slightly but not significantly' greater in the wet season following burning. The assessment of this research was that burning in the early wet is not of great benefit for animal production and brings with it a considerable risk if a poor wet season leads to a feed shortage in the subsequent dry season. The authors argue that it would be better to retain the 'moribund' material as a 'drought reserve' and utilise it with nitrogen supplements.

Implementation

- Burn the rank ungrazed sections of the paddock after the first heavy storm (40–50 mm of grass growing rain) early in the wet season.
- If the area burnt exceeds 50% of the paddock, wet season spelling is essential.
- The best results from fire occur when forecasts are for above average rain. During years of above average forage levels this practice also serves the purpose of hazard reduction.
- Avoid burning small areas of paddocks as this can create new patches of C land condition due to localised overgrazing.
- Avoid repeatedly burning the same location in subsequent years as this can result in wood vegetation thickening by removing grass competition with tree seedlings and suckers.
- Match the stocking rate to the new level of pasture available after burning.
- Do not re-burn areas for 4-5 years after burning.
- Be aware of the location of waters 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 years' burn as this can lead to overgrazing along the 'edges'.

Considerations and caveats

Similar results may be achieved by increasing the number of watering points, more subdivisional fencing or more lick points to encourage grazing of under-grazed areas and to attract cattle away from preferred areas and prevent the degradation of patches (refer to Chapter 10). However, these options are more expensive and labour intensive.

Generally country in good condition does not require spelling to grow enough pasture to carry a fire. However, wet season spelling may be required in subsequent years to prevent persistent patch grazing within the burnt area of the paddock. If the season following a burn is poor, burnt country may require at least two consecutive years of wet season spelling.

Permits, as required by law, should always be sought and the conditions followed for prescribed burning.

Restoration is not required for landscapes that are already in good condition however they do require protection. Monitoring on a regular basis and responding as necessary to any changes is the best way to prevent their decline.

Interactions – animal production, profitability, land condition and water quality outcomes

Managing stocking rates is the most important practice to optimise animal production and financial returns and to maintain land condition and high cover levels and hence prevent erosion and sediment loss. Land in good condition managed as described should continue to produce high levels of animal production in a profitable manner while maintaining the good land condition and having minimal effects on water quality. Burning may increase soil loss, so needs to be done in patches and at a time when ground cover is likely to recover quickly.

Toolbox

Karfs, R, Holloway, C, Pritchard, K & Resing, J 2009, *Land condition photo standards for the Burdekin Dry Tropics Rangelands: a guide for practitioners*. Burdekin Solutions Ltd & State of Queensland (Department of Primary Industries and Fisheries), Townsville.

For current DAFF workshops please refer to the Future Beef website ‹www.futurebeef.com.au›.

Chapter 7. Improving land in poor (C) land condition

A substantial part of the Burdekin region is in poor to degraded condition. This represents a major challenge to industry to improve management to increase productivity and to reduce potential impacts on water quality. While the previous section referred to situations where paddocks are in good (A or B) condition overall, this section will deal with pastures where the process of patch grazing has continued, unpalatable or low-productivity grasses have come to dominate the pasture, or 3P grasses have been generally grazed out over time and the paddock is now in poor land condition. Chapter 13 deals with land in poor condition as a result of many woody plants.

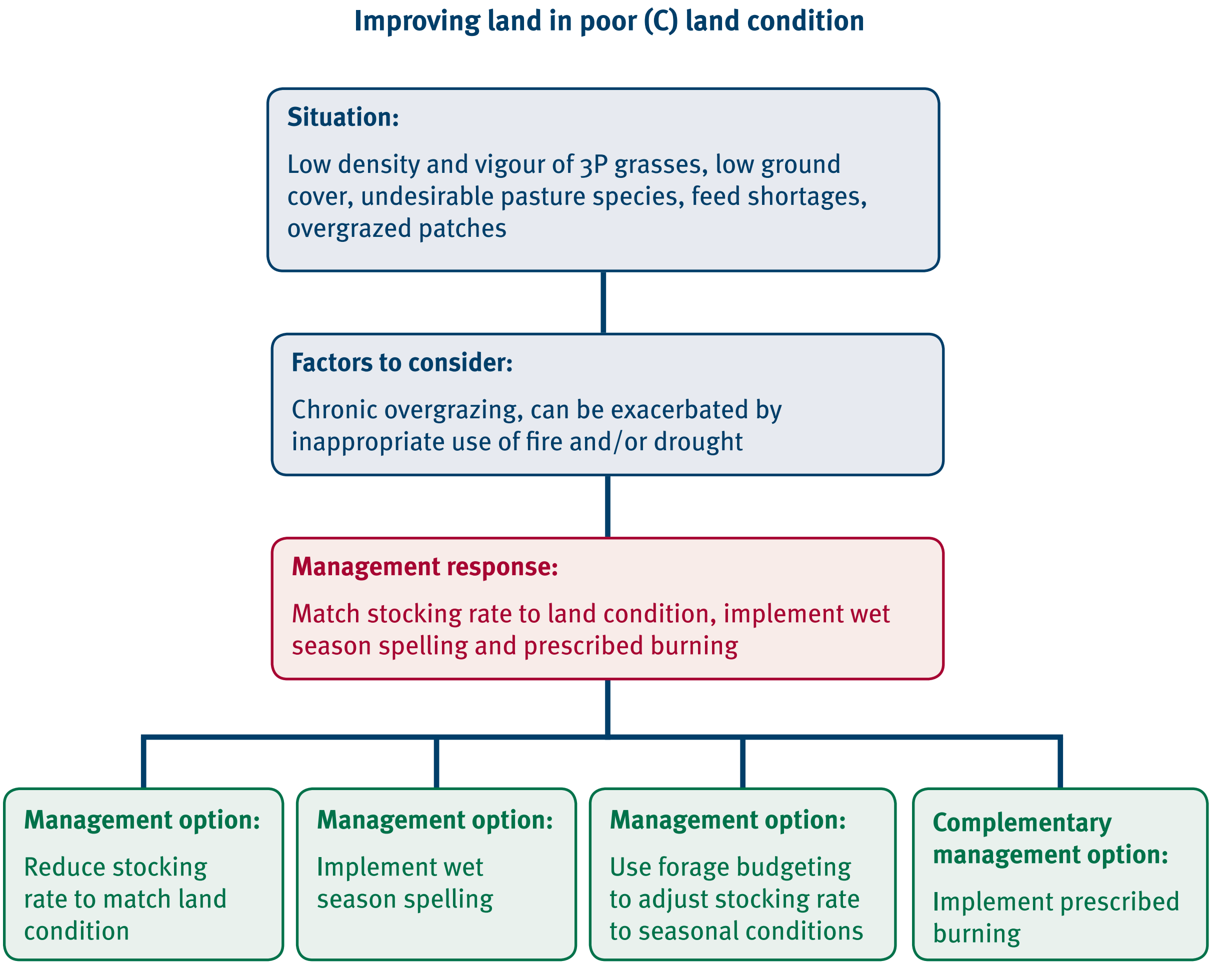

Figure 3. Diagram showing how this chapter on improving land in poor (C) land condition is structured.

Situation

Most of the paddock or particular parts of the paddock (e.g. preferred land types) are in C condition. There are two common scenarios:

- The amount of pasture is chronically low with a low density and vigour of 3P grasses (e.g. desert bluegrass and black spear grass); ground cover is poor with deteriorating soil surface condition, with some erosion and significant loss of moisture through run-off. Areas between remaining 3P grasses are dominated by low yielding annuals or less preferred perennials (e.g. slender chloris, summer grasses, button grass, five minute grass and sedges). Feed shortages may develop quickly in dry periods although high nutritional quality feed may be available for short periods after rain.
- Less palatable perennials - such as wiregrass - dominate yield but the 3Ps present are selectively grazed, weak and a low proportion of yield. In this scenario ground cover may be adequate and there appears to be a lot of pasture but little is useful for grazing stock.

Pastures that have lost 3P grasses in the Burdekin are found on all land types and often where cattle have patch grazed due to the area being both low in the landscape and having a longer growing season than adjoining hillslope areas and also being in close proximity to natural permanent waters.

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

Indian couch grass may dominate historically overgrazed patches or paddocks. While it provides ground cover and may prevent further soil loss and associated degradation it is not as productive as the native grasses that were present before the land declined to C condition. Cattle grazing Indian couch dominant pastures remove most of the material before it lignifies and becomes poor quality feed; therefore the diet quality is good initially but lasts only to the end of the growing season. This is followed by a feed shortage until the next growing rains. The overall carrying capacity and individual animal performance is reduced.

Indian couch makes poor quality standing feed during the dry season. This creates a dilemma for graziers as feed budgets, while ensuring good ground cover at the end of the dry, will not assist in ensuring a higher plane of nutrition. Hence most properties dominated by Indian couch will maintain high grazing pressures to have short nutritious feed for stock during summer and autumn and use supplements to carry stock through the dry. This spiral prevents an improvement in land condition.

Factors to consider

The primary cause leading to poor land condition is usually chronic and continuing overgrazing, which may be exacerbated by drought and/or intense wildfire events. Frequent and severe defoliation has deleterious effects on individual plants (by reducing their vigour) and on soils and pastures by reducing land condition (lower cover and more bare ground, lower infiltration and more run-off, altered botanical composition, patchiness). Drought and intense wildfire can sometimes damage an already weakened pasture.

The 3P grasses are often selectively grazed within the pasture leading to a reduction in plant size and vigour and eventually death. Seed production of 3P grasses may be prevented and recruitment of new 3P grass seedlings or vegetative spread is minimal.

With the demise of 3P grasses, plants able to survive heavy grazing pressure increase. These surviving plants may be quick growing and prolific seeding species (e.g. windmill grasses and Indian couch) or species with unpalatable traits (e.g. wiregrasses, Parthenium, giant rats tail grass) resulting in avoidance by livestock. Unpalatable traits may include tough leaf blades and stems, chemical deterrents or physical deterrents (prickles and spines).

Management response: Match stocking rate to land condition, implement wet season spelling and prescribed burning

Goal: limit animal numbers to minimise periods of feed shortage while using wet season pasture spelling (and sometimes fire) to improve land condition.

For paddocks in C condition, management needs to concentrate on recovering the 3P grasses through allowing new plants to germinate and establish, existing plants to recover or reducing competition from undesirable plants — or a combination of all three. This will generally require a combination of reducing stocking rates to match the current carrying capacity, introducing pasture spelling, managing animal numbers to minimise periods of feed shortage and waiting for the favourable conditions needed for 3P grasses to germinate and establish or recover. These actions may be complemented by prescribed burning where wiregrasses – or other fire-sensitive grasses – are dominating the 3P grasses.

The effect of fire on Indian couch is not known. Therefore increasing the percentage of 3P grasses is best achieved by regular wet season spelling and low stocking rates.

Management option: Reduce stocking rates to match land condition

Many areas of the Burdekin have large areas of C condition country dominated by wiregrass, annual grasses or Indian couch. While Indian couch grass can be palatable it is not as productive as native grasses and paddocks dominated by Indian couch suffer regular feed shortages. Continued over-grazing in this situation exacerbates the problem by pushing high grazing pressure onto remnant 3P grasses.

The underlying stocking rate needs to be sustainable by not exceeding the long-term carrying capacity based on the reduced pasture growth of C land condition country. Hence, reducing stocking rate to match land condition is the first step and is necessary for other management practices such as wet season spelling and fire to be effective.

Evidence

Under C land condition, long-term pasture growth is reduced to about half of that on land in A condition (e.g. McIvor, Ash *et al.* 1995). Attempting to maintain the same stocking rate as for A or B condition will result in chronic long-term overgrazing and exacerbate the decline in 3P grasses. Even when coupled with pasture spelling (e.g. one year in every four), lower stocking rates than for A land condition are required to increase 3P grasses. Land in good condition retains a high proportion of 3P grasses even at higher stocking rates and under a range of stocking strategies. In contrast, land in C condition only begins to improve under low stocking rates - even when combined with wet season spelling (refer to Chapter 7).

Implementation

- Recalculate long term carrying capacity for C condition country using the GLM workshop/ Stocktake approach accounting for land type and woody vegetation cover.
- Estimate long-term carrying capacity (refer to Chapter 6) based on the reduced average pasture growth within C condition. Average pasture growth may be further reduced if woody plants are a problem.
- Account for inaccessible areas within the paddock, such as those distant from water.
- Ensure that estimates adequately account for unpalatable or less productive grasses, such as wiregrasses, or estimates of carrying capacity will be too high and lead to continued degradation.
- Reduced stocking should be coupled with a wet season spelling plan to restore land to B condition (Chapter 7).
- Plans should account for rainfall variability by also introducing forage budgeting to avoid over-grazing 3P grasses (Chapter 7).
- Recovery of C condition land to A–B condition may take as long as 20 years.

Considerations and caveats

Recovery of C condition land to A/B condition may take as long as 20 years. Property size, debt levels and cash flow issues may be strong impediments to graziers reducing stock numbers over such a period.

Short-term factors such as unfavourable rainfall or cattle prices and increasing costs of production need to be accommodated during the recovery phase of land in poor condition.

Plans should be prepared to take advantage of favourable runs of good seasons or several years of good cattle prices, to commence land management changes. In the final analysis, these factors are always present; therefore improving land condition requires hard decisions otherwise carrying capacity will never improve and may continue to decline.

Currant bush often provides islands of 3P grass species and preferred sites for the rapid infiltration of rainfall in C condition landscapes. Annual wet season spelling will allow the colonisation of 3P grasses from seed that is produced under currant bush.

It may be necessary to manage for the proportion of C condition land in a paddock, rather than for areas in good land condition to affect a recovery.

For the Indian couch dominated pastures in north-east Queensland, minimum ground cover levels of 60% are recommended to control erosion (Post *et al.* 2006) but at least 90 percent cover is required to reduce run-off to low levels (Roth *et al.* 2004).

More research is needed on the impact of stocking rates, fire and wet season pasture spelling on Indian couch and weedy grasses e.g. grader grass, thatch grass, and giant rats tail grass. Options may include the use of temporary electric fencing to manage highly susceptible/ degraded areas in large paddocks.

Management option: Implement wet season pasture spelling

A realistic stocking rate will be most effective at restoring poor condition land when coupled with wet season spelling. Installing additional infrastructure may be useful to move stock away from preferentially overgrazed land types or to enable the application of pasture spelling.

Wet season spelling can allow 3P grasses to re-establish and an increase in available forage in subsequent years.

Evidence

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

Bio-economic modelling for the Burdekin in the NGS project suggests that wet season spelling can improve land condition from poor to good over time, provided stocking rates do not exceed the safe utilisation level. For the goldfields land type of the Burdekin, the modelling predicts improvement in land condition and the proportion of perennial grasses in the pasture when spelling was combined with a stocking rate of 8 ha/AE but not when combined with a stocking rate of 5 ha/AE. Even spelling for six months once every four years failed to improve land condition to any extent when the land was stocked too heavily. At the lower stocking rate of 8 ha/AE, land condition improved incrementally by increasing the length of spelling from two, to three or to six months once every four years (Figure 4).

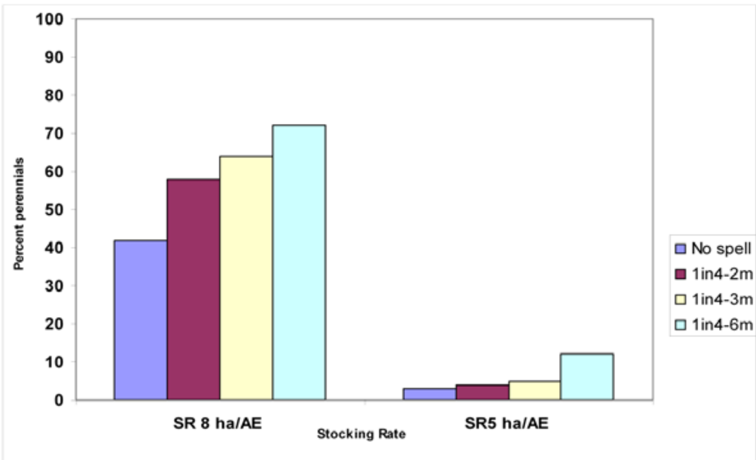

Figure 4. The combined effect of stocking rate (8 or 5 ha/AE) and spelling for two, three or six months once every four years on perennial grass recovery in the goldfields land type initially in C condition.

Based on rainfall patterns from 1980-2005, modelling indicated the proportion of perennial grass in the goldfields land type would have improved from 30% to 90% within 20 years (Figure 5) when spelling once every four years at the safe utilisation level. There would have been little improvement without spelling.

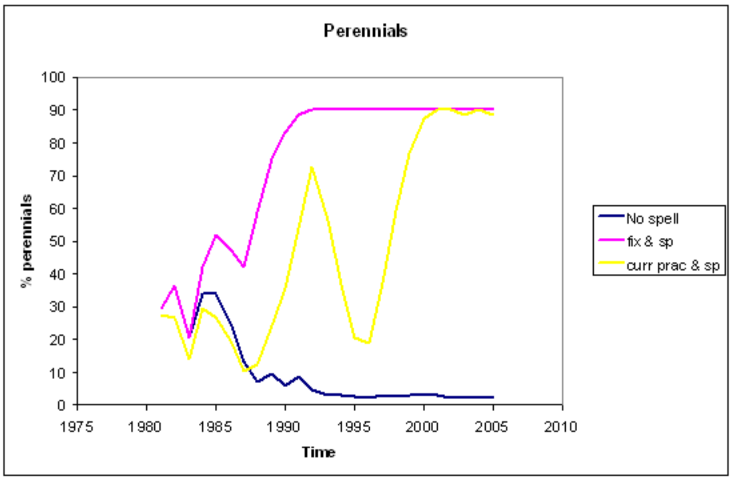

Figure 5. Change in perennial grass percentage with no spelling, spelling under a fixed stocking rate strategy (fix & sp) or spelling under current stocking rate changes (curr prac & sp) in the goldfield land type. Spelling is a fixed rotation of one year in every four over the whole wet season.

A trial at Belmont (Orr 2010) in central Queensland compared continuous grazing for the whole year with a summer spell (October-March). The proportion of buffel grass increased with a summer spell while the proportion of Indian couch grass and the undesirable snake weed decreased. The continuous grazing created gaps in the pasture allowing the Indian couch and snake weed to colonise. Although the trial showed grazing management could alter pasture composition, it was estimated that five to eight years of average or good rainfall would be needed for the changes to occur.

Star and Donaghy (2010) modelled the recovery of land from C condition to B condition at Virginia Park. Based on spelling for 6 months in both Years 1 and 2 and then for 4 weeks once every 4 years after that and assuming the land recovered to B condition by Year 2, the management scenario was economically viable although the outcome was influenced by the area involved and whether or not trees were present.

Implementation

- Wet season spelling should be coupled with stocking rates near long-term carrying capacity and the use of a feed budget approach to adjust stocking rate for seasonal conditions.
- Spelling means a complete destock of the paddock. Spelling regimes are characterised by their timing (seasonal), duration and frequency or number of the spell periods. A general recommendation for improving pasture condition is to have a planned but flexible regime to spell paddocks for the whole growing season commencing from the first rain event sufficient to initiate new growth (50 mm of summer rain over 2–3 days).
    - Plan which paddocks to spell first based on their current overall condition, the proportion in poor condition, the likelihood of success and the ease of implementation. The weaner paddock is often the easiest paddock to start a wet season spelling program in.

  Holding paddocks generally require an annual wet season spell as they are usually grazed at high utilisation rates during the year.
- It is generally easiest to remove cattle at the last mustering round of the dry season, although removing cattle at the start of the wet provides a longer period of grazing. If destocking is delayed until the start of the wet season, use feed budgeting to ensure ground cover targets at the start of the wet season are met.
- The length of spelling for poor condition pastures should be a minimum of eight weeks, however spelling for the whole growing (wet) season has been shown to be desirable particularly in below-average rainfall years.
- 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 produce seed. Newly establishing seedlings require time to grow and store root reserves to survive the following dry season.

- The required frequency of spelling or number of spell periods to achieve a certain goal will be determined by both initial land condition and growing conditions experienced during the spell period (pasture maintenance and recovery are boosted by good seasonal conditions). Establishment of seedlings from the seed set during an earlier spell period may be enhanced by a subsequent spell period. Refine management over time by monitoring the improvement in land condition.
- Increasing the frequency of wet season spells can be expected to give a greater pasture response but represents a trade-off as grazing is foregone during the spell period. There are no experiments in northern Australia dealing explicitly with comparisons of the frequency of spell periods and impact on land condition, but a number of trials provide useful information indicating that as land condition declines, pasture spells need to be more frequent if land condition is to be improved.
- Minimal gains will be made with spelling if stocking rates are not matched to feed supply and overgrazing occurs following the spell period.

Considerations and caveats

One approach to spelling is to increase cattle numbers over summer in the paddocks that are not being spelled. It is important to assess the trade-offs between the benefits to the paddock being spelled and the impact of increased grazing pressure in other paddocks that are carrying the extra cattle. There will be good gains in above-average rainfall seasons — especially when there is enough forage to easily spread cattle into the paddocks not being spelled. In below-average rainfall seasons, however, it will generally be necessary to reduce stock numbers across all paddocks to achieve light utilisation rates. This avoids the risk of over-grazing some paddocks when plants are already stressed due to a lack of rainfall.

The alternative to increasing stock numbers in other paddocks is to sell or agist the cattle from the paddock(s) being spelled. This removes the risk of over-grazing some paddocks. The economics of keeping the cattle from a wet season spelled paddock at home versus selling or agisting should be carefully assessed. It may be better to plan agistment during above-average rainfall seasons when it is likely to be cheaper due to low demand. Wet season spelling under these conditions will maximise the rate of recovery in land condition.

The length of the spell will influence the decision to agist e.g. shorter duration spelling is easier to accommodate within the property, long duration spelling may favour agistment. The class of cattle may also affect the decision to use agistment to spell country; in general terms agistment is easier with dry cattle (steers and spayed females) while breeders are more problematic to agist. Herd models may be a useful tool to help decide which classes of cattle to sell.

The likelihood of drought should be considered in the pasture spelling plan. More frequent and/or earlier adjustments to cattle numbers may be required in low rainfall years e.g. adjust in February rather than April/May by selling slaughter cattle that meet the desired market specifications and reducing breeder numbers by culling obvious free-loaders.

If prescribed burning is part of the overall property management plan, it should also be considered when implementing pasture spelling e.g. to promote recovery of the pasture following burning or to build sufficient fuel to burn.

Infrastructure may need to be modified to ensure that preferred land types can be wet season spelled and stocked at appropriate levels. Factors to consider include:

- Adequacy of stock water distribution.
- Number and area of current of paddocks.
- Cost benefit of additional fences and water points including ongoing maintenance and running costs.
- Complexity of land types within existing paddocks.
- Possible reduction in diet selection due to restriction of access to a range of land types throughout the year.
- Likelihood of obtaining an increase in production to cover the extra capital investment.

- Area of each land type within each paddock and whether each will carry sufficient cattle to make it worth subdividing e.g. subdivision into smaller paddocks may be suitable if they are near the house or yards. In the remote parts of the property, a rule of thumb is to subdivide land types where they are capable of sustainably running at least 100 AE (maybe less for smaller properties).

Management option: Use forage budgeting to adjust stocking rate to seasonal conditions

Forage budgeting is an important component of restoring land in C condition — especially when the pasture is dominated by Indian couch and annual grasses. The same principles and strategies apply as for land in good condition (Chapter 6) but it is likely that the country is most suited to short grazing periods (e.g. 90-210 days) rather than annual budgets. C condition country may be best suited to backgrounding operations and is unlikely to be suited to breeding operations — especially if trying to restore land condition. If large areas of a property are in C condition it may be appropriate to have a low number of (or no) breeders and concentrate on restoring land condition with cattle classes or enterprises (e.g. short term agistment) that offer the most flexibility in de-stocking.

Evidence

It should be self-evident that feed budgeting is essential in situations where feed commonly runs out towards the end of the dry season. However this situation has not been studied under experimental conditions. The Wambiana grazing trial is the major site to experimentally compare stocking rate strategies but has not specifically addressed pasture recovery from poor condition, as it started in good condition and has studied the decline in land condition due to over-grazing.

Implementation

- 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, use plant and soil indicators to inform decisions about the need to reduce stocking rates to avoid land degradation as pasture availability and seasonal conditions decline. The condition of 3P grass tussocks (such as the amount of residual yield or stubble height) are important indicators of future plant survival and pasture productivity.
- Reducing stocking rates late in the wet season may encourage seed production by 3P grasses.
- Maintaining minimum levels of ground cover is important for protecting the soil.
- Stocking rates should be reduced in poor years of below average pasture growth, especially during poor wet seasons (because of the sensitivity of 3P grasses to grazing at this time). Plans for a progressive reduction in stocking rates during deteriorating seasonal conditions should be developed to avoid crisis management.
- Develop a forage budget at the start of each winter for the coming 6–8 months. If conditions remain dry into the next summer and pasture growth is insufficient to support existing stock numbers, further adjustments will be required.
- Tools such as Stocktake are available to help in developing a forage budget. Seasonal forecasts (as explained above) can assist with decisions on whether to retain existing stock numbers. These tools can assist graziers in making decisions to sell stock early and avoid selling stock in poor condition onto flooded markets with depressed prices.
- The ground cover photo standards and their respective yields for Burdekin land types is a very useful tool (Karfs *et al*. 2009b).

Considerations and caveats

Good growing seasons with an ample supply of feed may be an opportunity to spell pastures to improve condition (Chapter 7) and/or to use fire to manage woody plant populations (Chapter 13).

Arriving at an estimate of pasture yield for a poor condition paddock is often difficult because of variations in yield and species composition across a paddock. It helps to break the paddock into areas of different yield and estimate their proportions of a paddock to give a weighted average yield. For example in a paddock with 10% bare area and a pastured area with a yield of 2 000 kg/ha, multiplying the yield by 90% will give a weighted average of 1800 kg/ha. Not accounting for the bare areas may have led to overstocking of the pastured areas.

Complementary management option: Implement prescribed burning

Prescribed burning may have a role in reducing fire-sensitive and unpalatable grasses. Most of the related research has been conducted further south than the Burdekin.

Evidence

Some grass species are sensitive to fire (e.g. some wiregrasses in the Burnett region). Fire can be used to manipulate pasture species composition by killing certain 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 target unpalatable grass species (e.g. different types of wiregrasses). Some unpalatable grass species may be encouraged by fire. The fire regime may also encourage other desirable species.

Vogler (pers. comm.) is currently assessing the impact of fire on grader grass an exotic annual grass that is invading large areas of the Burdekin woodlands and southern Cape York Peninsula. Preliminary findings indicate that burning soon after seed set can reduce the amount of grader grass in the following season by burning the current seasons' seed lying on the ground.

Work at Injune, as part of the Aristida-Bothriochloa project, found that the frequency of two desirable grasses (forest blue grass and Queensland blue grass) was higher with fire. They recommended using fire every two to four years to manage pasture composition but concluded more frequent fires could be detrimental.

Many native grasses have some tolerance of fire and some of the 3P species are favoured by it e.g. black spear grass and kangaroo grass. Although they are both fire climax species the timing of fires for each is slightly different. Kangaroo grass (and other grasses) can be damaged by wet season fires when actively growing. The point is that while most native species are tolerant of fire to some extent, it is the timing and intensity that is important for the species in question.

If fire is to be used to manage pasture composition, it is preferable to use a mild fire and burn at the start of the wet season after 25–50 mm of rain. The pastures can regrow after the fire to give ground cover in the event of further storms and provide forage for stock. Burning within a couple of days after rain also helps to retain litter as ground cover. The litter remains moist for a short period and is less inclined to burn.

Implementation

- Implementing a fire regime requires planning to ensure adequate fuel is available. This may mean adjusting stocking rates or spelling to preserve fuel followed by wet season spelling in the post fire period to encourage the recovery of desirable pasture species.
- Additional infrastructure may be useful to enable smaller areas to be burnt at one time.
- 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 pasture 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 influence capacity for effective fires.
- Timing of fire is important. Fires in the late dry season or early wet season will remove rank growth and top-kill woody plants but cause less damage to perennial grasses than fires later in the wet season which will reduce the vigour of perennial grasses. Fires in the early dry season may favour woody plant suckering through removal of grass cover.
- Post-fire spelling and setting stocking rates will be critical for maximising any benefits

of using fire to manage pasture species. Where there are few desirable plants there may be little positive response to prescribed burning in the short to medium term.
- Look for opportunities to address two or more 'purposes' with the same fire regime (e.g. manage a woody plant and an unpalatable grass).
- Consider the risk of a low rainfall season and have strategies in place if the season following burning has low rainfall.
- List paddocks in a priority order for burning and start with the top priority paddock after the first fall of sufficient rain. As more rain is received progress to the next paddock until it becomes too late in the season to continue with burning. Be wary of burning too much country and risking feed shortages if there is no follow up rain.
- Always burn at least a third of each paddock so stock preferentially grazing the recovering burnt area do not cause damage and a further decline in land condition; or preferably burn whole paddocks followed by a wet season spell.

Considerations and caveats

Consider the number of summers that wet season spelling may be required to promote 3P grass recovery following the burn. The use of fire in poor condition land will generally need to include at last one full wet season spell to promote the 3P grasses to out-compete remaining undesirable grasses.

Not all wiregrasses are sensitive to fire or respond the same way in different regions. The Aristida-Bothriochloa project and work in the Burnett (Orr and Paton 1997) both found that dark wiregrass is sensitive to spring fires. While purple wiregrass was sensitive to fire in the Burnett, it was not affected by burning within the Aristida-Bothriochloa project (near Injune and Emerald). In the Burnett, both wiregrasses declined in yield and as a proportion of pasture over the three years of the trial and the 3P grass black spear grass became dominant.

The differing results with wiregrasses may reflect different fire conditions, or it may be because dark wiregrass has a crown above ground which is more susceptible to fire whereas purple wiregrass crowns are largely below ground and somewhat insulated from the effects of fires (Silcock, pers. comm.).

Even when the wiregrass is not controlled with fire, burning wiregrass-dominant pastures can help to remove the overburden of old growth on wiregrass plants and open up the pasture to allow other species to compete more favourably. This practice is often employed by local landholders in the Burnett.

Permits, as required by law, should always be sought and the conditions followed for prescribed burning.

Interactions – animal production, profitability, land condition and water quality outcomes

Reductions in animal numbers during the restoration phase can be expected to reduce animal production and financial returns but the bioeconomic modelling shows the long-term returns are positive. Land condition will improve over time and with the increases in ground cover, run-off and soil movement should decrease leading to improvements in water quality. Burning may increase soil loss, so needs to be done in patches and at a time when ground cover is likely to recover quickly.

Toolbox

Department of Environment and Heritage Protection, *ReefWise Farming*, State of Queensland (Department of Environment and Heritage Protection), ‹www.reefwisefarming.qld.gov.au/›.

Department of Natural Resources, Mines and Energy 2004, *Pasture degradation and recovery in Australian Rangelands: Learning from history*, State of Queensland (Department of Natural Resources, Mines and Energy).

Karfs, R, Holloway, C, Pritchard, K & Resing, J 2009, *Land condition photo standards for the Burdekin Dry Tropics Rangelands: a guide for practitioners*. Burdekin Solutions Ltd & State of Queensland (Department of Primary Industries and Fisheries), Townsville.

For current DAFF workshops please refer to the Future Beef website ‹www.futurebeef.com.au›.

Chapter 8. Stabilising and recovering land in very poor (D) land condition

Recent national imperatives have focussed attention upon land condition in the Burdekin catchment and the quality of river run-off to the Great Barrier Reef (GBR) lagoon. Assessments across the Burdekin woodlands over the period 2004-2007 estimated 6% of pastures to be in very poor (D) condition (Karfs *et al*. 2009). These 'hotspots' of very poor condition contribute substantially to run-off, sediment loss, and poor water quality.

Stabilising and recovering land in very poor (D) land condition

Situation:

Significant soil erosion, substantial weed infestation, very low to no ground cover, very few or no 3P grasses

Factors to consider:

Chronic and continued overgrazing, invasions of aggressive weeds, loss of 3P grasses and ground cover

Management response:

Emphasise improving land condition and water quality outcomes

Management option:

Fence to control grazing and reduce stocking rate

Management option:

Increase water infiltration on bare, scalded areas

Management option:

'Starve' gullies of water

Management option:

Control and manage woody weed populations

Figure 6. Diagram showing how this chapter on stabilising and recovering land in very poor (D) land condition is structured.

Pasture in very poor degraded (D) condition is unproductive and requires extensive (and expensive) intervention to improve ground cover and reduce water, soil, and nutrient loss for its rehabilitation. Land in D condition will not simply revert back to C condition with a change in stock management, at least not in time-frames of practical interest and normally requires major mechanical and/or chemical intervention (Quirk and McIvor 2003). Currently, there is little reliable information on the most effective and efficient mechanical treatments to achieve a systematic reduction in erosion and nutrient loss across a range of land types, areas and gradients, with differing weather patterns and other relevant variables. More survey work and scientific study is required to advance our knowledge in this area.

Restoration of an ecosystem is less desirable than the prevention of degradation. Restoration can rarely reproduce the condition of the former landscape, as severe or large-scale degradation may result in the permanent loss of species or genetic material from a local area.

Situation

Very poor (D) condition land will show signs of some or all of:

- significant soil erosion
- substantial weed infestation
- very low to no ground cover
- very few or no 3P grasses
- often approaching desertification in appearance.

Recent use of satellite imaging tools like the VegMachine software (Beutel *et al.* 2010) and FORAGE (Timmers *et al.* 2008, ‹www.longpaddock.qld.gov.au/›) has provided landholders and resource personnel with a more targeted method for identifying hotspot areas of bare ground or low ground cover across properties and land systems. This information, supported by on ground measurement and observation has multiple benefits. In addition to assisting identification and assessment of D condition hotspots, it can also link historical management practices to ground cover outcomes for improved management and assist ongoing assessment of management interventions in D condition hotspots (refer to Figures 7 and 8).

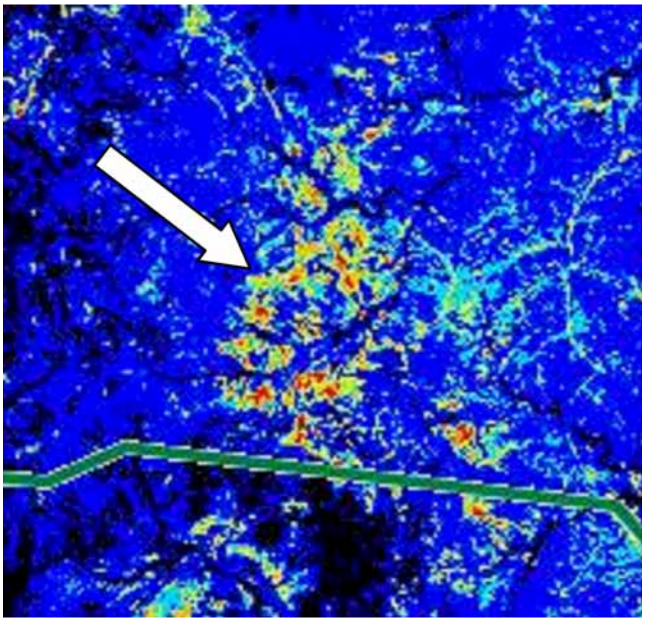

Figure 7. Red/orange/yellow shading in the VegMachine image identifies potential D condition hotspots based on persistently low ground cover. The arrow indicates a subsequent ground inspection site where a large network of gullies was identified (Figure 8).

Figure 8. Gully network initially identified using VegMachine Cover image. Lost topsoils and exposed subsoil with poor moisture retention have led to tree death. The photograph was taken at the location identified in Figure 7.

Factors to consider

Very poor (D) land condition is usually the result of chronic and continued overgrazing with the loss of 3P grasses and ground cover to the point that erosion and/or scalding dominates the area. Removal of ground cover allows rain and runoff to scour soil that was previously sheltered by vegetation and litter and held in place by root mats. D condition land can also result from invasion of aggressive weeds, which may be exacerbated by chronic overgrazing.

Management response: Emphasise improving land condition and water quality outcomes

Goal: to restore D condition land to better condition, preferably A and B.

If country is allowed to degrade to D condition, the only options are high cost reclamation techniques such as ripping/blade-ploughing and pasture sowing. These are often only economic on D condition land with better fertility soils, or perhaps scalded areas. These options are only effective when followed by annual wet season spelling and light grazing until the area is dominated by a dense cover of 3P pasture species. The on-going management must maintain the improvement in land condition (including follow-up weed and feral animal control) resulting from the reclamation work.

The form of degradation will determine the most appropriate management response. While all forms of degradation (weeds, erosion, scalding, the loss of 3P grasses) may occur in combination (Mortiss 1995) it is useful to consider three major types as the management actions vary between types. The types are:

- large bare, scalded or rilled areas
- extensive gullying
- woody weed thickets.

Management option: Fence to control grazing and reduce stocking rate

In most cases for all three types of degradation there will be few or no 3P grasses and ground cover will be low. Irrespective of type of degradation it will be necessary to control and limit grazing.

Situation, assessment, considerations and caveats

Treated areas will generally need de-stocking to promote recovery, or at least reduced stocking rates coupled with wet season spelling. Grazing should be excluded from D condition hotspots being treated for a number of consecutive wet seasons e.g. fencing livestock out of smaller areas or de-stocking paddocks where larger areas are being treated. The length of time needed for D condition land to recover will depend on wet season rainfall and the success of the chemical or mechanical method chosen. Typically, at least 5-10 years is needed to recover degraded country. Overall property management plans should account for the reduced carrying capacity for this time.

Management option: Increase water infiltration on bare, scalded areas

Bare, scalded areas caused by overgrazing will still be very slow to recover even if fenced to exclude stock and additional work is required to fully restore the site.

Evidence, implementation, considerations and caveats

Once degraded, bare surfaces continue to run water instead of allowing rainfall to infiltrate into the soil.

There are four key aspects to a soil restoration project:

- Recognising cause and effect and targeting the cause
- Site stabilisation
- Environmental reconstruction
- Monitoring.

A stable site where the cause of the degradation is removed is much easier to rehabilitate and improve than an unstable site that is still in decline.

Re-establishing pastures and improving ground cover is the key to restoration of degraded landscapes and its management will be the single most important consideration in any restoration project. Pasture is vital for stabilising soil, improving productivity, maintaining habitat and biodiversity. Many studies show that the amount of run-off and soil loss from grazing land is substantially mitigated by ground cover (Gardener *et al.* 1990; McIvor, Williams *et al.* 1995; Scanlan *et al.* 1996) and differences between grazed and ungrazed areas could be attributed solely to differences in cover. Perennial grasses help capture more rainfall than annuals - reducing run-off, erosion, and soil loss.

Mechanical options for erosion and scald reclamation, such as deep ripping, chisel ploughing, pitting using a crocodile seeder, ponding, and contour banks have been successful when combined with de-stocking (Roth *et al.* 2003). Graders and other heavy machinery can be used to break the surface of scalded areas to inhibit overland water flows and to reduce sediment run-off and aid infiltration. Where remnant 3P grasses remain they may recruit but it will often be necessary to sow grass seed. Once grass cover is re-established it is important to manage these areas carefully to allow litter and other organic material to accumulate and the soils to recover.

Practical experience and research has shown that successful perennial grass re-establishment requires attention to a range of desirable conditions and implementation factors including:

- adequate subsoil moisture – the major risk of poor establishment
- effective weed control
- good seed quality/treatment
- shallow sowing depth
- best sowing time
- adequate soil fertility
- good grazing management.

Star and Donaghy (2010) modelled the recovery of land at Virginia Park from D condition to B condition. The area treated was ploughed and sown to introduced pastures. The area was assumed to remain in D condition for Years 1 and 2 and to recover to B condition from Year 3 onwards. Based on these assumptions the scenario was economically viable although dependent on the area whether all or only part of the paddock was treated and whether or not trees were present.

Management option: 'Starve' gullies of water

Fencing to exclude cattle can be complemented by the judicious establishment of grassed, flow diversion banks along the contour line just upstream of the gully heads to 'starve' the gully heads of further run-off from upslope areas. Since gullies typically form close to water courses, when fencing out frontage country it may be possible to include as many gullies as possible aiding their subsequent management.

Evidence, implementation, considerations and caveats

From their review of water quality benefits from improved management, Thorburn and Wilkinson (2012) concluded:

1. Reducing runoff from upslope into the gully decreases the rate of headward extension of the gully and hence sediment yield, as headward extension is correlated with runoff. Reducing runoff also decreases the sediment transport capacity of the gully channel, so increasing retention of mobilised sediment within the gully.
2. Increasing cover on gully walls decreases sheetwash and rill erosion from the walls. The threshold for initiation of incision of new gullies is also sensitive to the erosion resistance of the hillslope surface.
3. Reducing the sediment transport capacity of the gully channel, by increasing roughness, enhances sediment deposition on the gully floor reducing net export of sediment from the gully and promoting vegetation establishment.

Where gullying is extensive, the first step as part of recovery from D condition is to stabilise the gullies. Often considerable earth works may be required. Here, the primary function is soil conservation requiring structures to control run-off water by intercepting it and transferring it safely into a drainage line or a broad stable ridge. Structural works for water erosion control are site specific and require specialist design, survey and construction. Such works include dams, banks, waterways and flumes. There are principles established relating to the design and construction of channels, diversion banks, contours, and waterways, such that erosion is minimised. Earthwork design needs to incorporate provision for risk, in this case the likelihood of further adverse events i.e. frequency or average recurrence interval of events which may cause further soil loss and gully erosion. For example, contour banks to moderate overland flows need to be designed so that they will hold for say, a one in 10 year event and for an acceptable velocity of water runoff. For more information refer to Department of Natural Resources and Water (2004).

The design and construction of contours or flow diversion systems is a risky option; if poorly designed such systems can actually exacerbate gully erosion, particularly on vulnerable soils (e.g. sodic duplex soils). Hence, such approaches will require a properly engineered plan. On well-drained alluvial soils, gully remediation using earth-moving machines followed by mulching and seeding of improved pasture species into the in-filled gullies has been reported to be a feasible option to not only to stop further gully erosion, but also to recover gullied and dissected frontage areas for grazing (Roth *et al*. 2003).

Most areas where gullying occurs and water diversion is planned are not major streams but if arterial streams are involved then legislative requirements need to be followed.

Irrespective of the strategy used, any measures involving soil disturbance for contour bank construction, ripping of scalded areas to enhance seeding and in-filling of gully sections will require cattle exclusion for at least one if not several seasons to ensure a successful establishment of pastures. The use of electric fences may be an economical alternative to conventional fencing for those situations where only temporary fencing-off is required. Costs of electric fences are about a third of those for conventional fences, but maintenance can be labour intensive.

Management option: Control and manage woody weed populations

Where woody weed infestations are extensive they will require management to prevent them expanding further and to reduce their competition with re-establishing pastures.

Evidence, implementation, considerations and caveats

The principles of weed management include:

- Be aware of all existing and potential weed species
- Prevent the introduction of new weeds and the spread of those already present
- Detect weed infestations early
- Intervene early in the process of weed invasion and spread
- Integrate a variety of management techniques
- Act strategically against weed infestations (e.g. by spraying before seed set; control isolated plants and from the upstream edges of established populations).

Managing woody weed populations is dealt with in detail in Chapter 13 where the emphasis is placed on the role of prescribed fire. However, when dealing with D condition country, it is unlikely there will be sufficient herbage to provide fuel for a fire so spraying and/or dozing/cutting will be required to manage weed infestations. Chemical and mechanical weed control has been successful in the Burdekin when it forms part of an overall grazing management plan. In some cases, the use of specific grazing animals e.g. camels or goats, has been successfully integrated into the control strategy (Anon. 2006 ‹www.wetlandcare.com.au/›). Eradication is rarely a realistic objective. In most cases, eradication is possible only when a concerted effort is made with large resources early in the invasion process when the infestation is very restricted.

In most situations degradation has happened over an extended period of time so some type of quick fix is unavailable. An effective response – particularly considering the costs typically involved – may require a sustained and concerted long term effort. Such a response is requires a consistent allocation of resources as a means of 'chipping' away at the problem. Smaller, family enterprises (70% of grazing enterprises in the Burdekin are family owned) may find this approach more manageable as access to significant resources may be limited.

Some scenarios and options

The five scenarios below look at options for improving degraded 'D' condition land where there are claypans, scalded sloping land, a single gully, a network of gullies and an eroded access track. The information was derived from GLM program – Reclamation of 'D' condition land in the Burdekin rangelands.

Note - seek expert advice before proceeding with any reclamation work.

Scenario 1. Claypan – scalded area, flat land

Treatment options:

- establish temporary supplementary feeding point for small areas
- may need to divert water
- for slopes less than 0.5%:
  - shallow water ponding
  - chequerboard ploughing
  - spiral ploughing

Scenario 2. Scalded sloping land – 1500 ha area (whole paddock), 2% slope, marginal soil fertility, small patches of Indian couch

Treatment options:

- Exclude stock
- Suitable on any slope
  - contour ripping (strips)
  - pitting (e.g. crocodile seeder)
  - chisel plough whole area
  - blade plough
- Sow pasture seed with all of the above

Scenario 3. Single gully – with 15 ha catchment, less than 1 ha area on moderately erodible soil, marginal fertility with topsoil 20 cm deep

Treatment options:

- exclude stock
- divert top water to stable site e.g. ridge top
- stockpile topsoil from gully margins
- reshape gully heads and sides
- replace topsoil (no seeding)
- contour rip catchment to reduce run-off volume and seed

Scenario 4. Network of gullies – catchment 5 to 10 ha on dispersible, shallow, low fertility soils

Treatment options:

Note: Very difficult and high risk to treat successfully

- exclude stock
- divert top water to stable site
- shallow rip (10 cm) or crocodile/chisel plough catchment and seed
- treat one gully head as a trial

Scenario 5. Eroded access track

Treatment options:

- If track is poorly located – 'put to bed' and move to better location
- If location is suitable – proceed with rehabilitation by constructing whoa boys across the track (seek expert advice on construction)

Interactions – animal production, profitability, land condition and water quality outcomes

Animal production from country in D condition is already low, so impacts on animal production will be small even if areas are totally destocked. Costs of stabilising and recovering D condition land are high, so in the short term, costs will exceed income for these areas. However land condition will improve and in the longer term there will be major improvements in water quality. The only least cost option for managing D class land to improve water quality is to reduce stocking rate in paddocks further up the catchment.

Toolbox

Abbott, B, Perry, J & Wallace, J 2008, *Land condition monitoring in the Rangelands of the Burdekin Dry Tropics Region. Task 4 – Prioritisation of D condition Land for Rehabilitation*, Burdekin Solutions Ltd, Townsville.

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Karfs, R, Holloway, C, Pritchard, K & Resing, J 2009, *Land condition photo standards for the Burdekin Dry Tropics Rangelands: a guide for practitioners*, Burdekin Solutions Ltd & State of Queensland (Department of Primary Industries and Fisheries), Townsville.

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Timmers, P, Zhang, B, Panjkov, A, Stone, G & Day, K 2008, 'FORAGE – A web-based framework for generating decision support information for sustainable grazing land management', *Proceedings of the Australian Rangeland Society Conference*, Charters Towers.

For current DAFF workshops please refer to the Future Beef website ‹www.futurebeef.com.au›.

Chapter 9. Improving frontage country and wetlands

Frontage country (refer to Figure 10) is the area along rivers and wetlands, which contains the riparian zone and associated floodplain and generally extends from the waterway/wetland to the start of the upland area. Frontage country comprises a small proportion of grazing properties but often is the most productive land because of higher levels of moisture and nutrients than in upland areas. Frontage areas are attractive to cattle due to more nutritious pasture, water supply, and available shade. They link the upland areas to streams and are an important part of the flow of water (and soil and nutrients) in the landscape. They can protect the streambanks from erosion, act as sinks for nutrients, and have many production and environmental values for the property.

Improving frontage country and wetlands in poor condition

Situation:

Frontage country and wetlands – bare soils, erosion, gullies, poor vegetation, weeds and eroding stream banks

Waterways and wetlands – poor vegetation, highly turbid water, pugging and algal blooms

Factors to consider:

Animals prefer to graze in frontage country and wetlands for forage, shade and access to water – leads to overgrazing and woody weed invasions

Management response:

Control grazing pressure and other disturbances in frontage areas

Management option:

Control cattle access with fencing and off-stream water points

Management option:

Control grazing pressure with moderate stocking rates and wet season spelling

Management option:

Support good production & environmental health with regular weed and pest control

Figure 9. Diagram showing how this chapter on improving frontage country and wetlands is structured

Different parts of frontage country have different values and require specific management, including the floodplain (contained in frontage paddocks), riparian areas and the waterways or wetlands themselves.

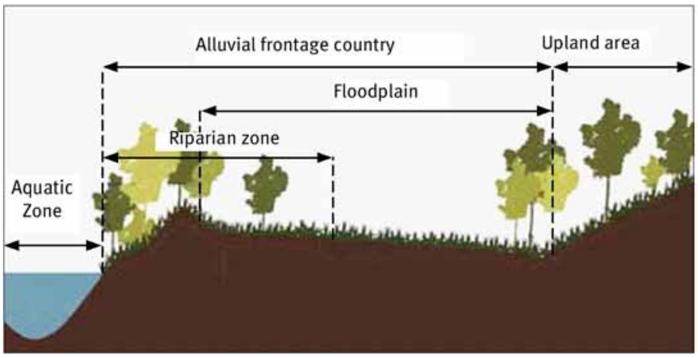

Figure 10. Alluvial frontage country (includes the riparian zone and floodplain). Adapted from Coughlin *et al.* (2008).

Trees, shrubs and grasses are all important for the stability, productivity and filtration capacity of frontage country, riparian and wetland areas. The grass layer slows the flow of water reducing erosion and increasing infiltration as well as filtering soil and nutrients from the run-off. Trees and shrubs along a stream and within wetlands help cycle nutrients, provide shade and habitat, reinforce the banks by holding soil together and also dry out the soil helping to prevent soils from becoming saturated and slumping.

Situation

Signs of poor condition frontage country and wetlands include:

- Floodplain area: bare soils and erosion, gullies and weeds.
- Riparian areas: poor vegetation health or structure (i.e. trees, shrubs and ground cover), eroding streambanks
- Waterways and wetlands: poor vegetation health, highly turbid water, pugging and algal blooms.

Factors to consider

Concentration of stock and/or other herbivores through preferred grazing in frontage areas and wetlands is a major cause of degradation. In paddocks containing a mix of frontage country and upland areas, stock tend to spend more time grazing the frontage area. This selective grazing can reduce land condition in frontage areas even though the paddock as a whole is not overstocked.

These areas are attractive to cattle for shade, access to water and forage. Cattle can impact on these areas by:

- decreasing ground cover by grazing. Bare patches in frontage country can concentrate the flow of water increasing the risk of sediment finding its way to waterways and rills and gullies forming
- grazing sensitive riparian and wetland vegetation
- compacting soil and causing tracks that concentrate the flow of water leading to erosion
- damaging and destabilising banks where they enter streams,
- stirring up sediments and causing pugging within the waterway
- urinating and defecating in the water.

Weed invasion can be a major problem in frontage country as weeds can be introduced via floods and then establish in disturbed areas, flourishing in the favourable growing environment

Feral pigs can cause major disturbances in frontage areas by digging up the soil, destroying ground cover and leaving the disturbed areas prone to weed invasion.

Management response: Control grazing pressure and other disturbances in frontage areas

Goal: to minimise run-off of water and nutrients while obtaining a sustainable level of grazing.

Much of the management is the same as for upland areas depending on land condition (refer to earlier sections). However frontage country and wetlands warrant special management because of its production and environmental values. Management needs to assess how grazing pressure can be adjusted to reduce overgrazing in frontage country and wetlands. Refer to Chapter 5 for information on monitoring (combined with record keeping) and forage budgeting to help determine suitable stocking rates for these areas.

Management option: Control cattle access with fencing and off-stream water points

Managing grazing through fencing frontage country and the use of off-stream water points has production and environmental benefits (Coughlin *et al*. 2008). It provides a means of controlling access and grazing pressure to maintain productive frontage pastures and minimise impacts on waterways and wetlands.

Depending on the width of the frontage country, current condition and management priorities a landholder may choose to manage grazing through one or a combination of these infrastructure options:

1. Fencing between frontage and upland areas to enable specific management of the frontage country
2. Fencing between floodplain and riparian area to manage access to the waterway or wetland. Fencing off riparian areas can stop cattle accessing waterholes and reduce erosion as cattle tracks leading to the streambed are often a trigger point for gully incision and bank erosion.
3. Off-stream watering to encourage stock away from waterways and wetlands (this also can have cattle health benefits).

Complete exclusion is unlikely to be necessary, especially for ephemeral streams in the Burdekin catchment, where managed grazing can occur with minimal impact on waterways. Most damage is likely to occur when banks are very wet and hence prone to slumping and at the end of the dry season when cattle (and other animals) congregate around dwindling water holes that act as a refuge for aquatic organisms. Restricting cattle access to waterholes at this time is critical to maintain good ambient water quality.

Note restricting cattle access to these areas for the first rains of the wet season will reduce the risk of fresh dung polluting waterways.

Irrespective of whether cattle are excluded completely or only for periods, fencing provides a mechanism to control cattle access and hence grazing pressure.

Evidence, implementation, considerations and caveats

Although fencing can be difficult and expensive, fencing off frontage country (between hillslope/upland areas) means that this area can be managed as a separate unit. Grazing pressure (time, intensity and duration) can be adjusted promote productive pastures and avoid overgrazing. Fencing off riparian areas can also help when mustering. When cattle access is restricted e.g. during wet season spelling and streams serve as the water supply for a paddock, additional off-stream water points are needed. Off-stream watering may have additional cattle health benefits and drinking from troughs is generally preferred by cattle.

Management option: Control cattle grazing pressure with moderate stocking rates and wet season spelling

Control of cattle is essential to manage the selective grazing of frontage country. Like other areas on properties, moderate stocking rates are important to maintain stock production and to avoid overgrazing. Frontage country is generally more productive than upland areas, so that the potential production benefits from good land condition are significant. Based on these values, these areas can be good for weaners or fattening stock. Frontage country can benefit from regular wet season spelling to attain good land condition. Spelling for the full wet season helps to recover areas that have been preferentially grazed.

Evidence, implementation, considerations and caveats

The information on evidence, implementation, considerations and caveats of stocking rates has been presented earlier in Chapters 6 and 7.

Due to frontage country values, the end of dry season ground cover should be greater than 60% and even during drought years, should not fall below 40%.

Management option: Regular weed and pest control

Although pests may be a problem in some cases (e.g. pigs) the major problem in frontage country and riparian areas is weeds. Weeds can smother riparian and wetland vegetation, compete with pastures in the frontage country and lead to erosion. Weed management in frontage country is similar to upland areas, but due to the productive soils, sensitive riparian vegetation, and adjoining waterways and wetlands, caution needs to be taken when managing weeds.

Evidence, implementation, considerations and caveats

Chapter 13 covers managing woody weeds and serves as the basis for managing weeds on frontage country. The build-up of grass following the introduction of a more conservative stocking rate as previously outlined provides the additional benefit of being able to use fire as a tool to control rubber vine and other weed infestations along stream and riverbanks. Indeed, sometimes the ability to manage woody weeds on river frontages may be a more important reason for fencing off frontage country than controlling sediment export, but the two strategies are entirely compatible.

Fire needs to be used with extreme caution in frontage country and particularly riparian and wetland areas. There is limited information available on the use of fire in frontage country in the Burdekin (Coughlin *et al.* 2008). Some riparian and wetland plant species are susceptible to fire, especially intense fires and it could lead to death, resulting in potentially worse weed problems. Fire use needs to be considered in terms of the management objectives, for instance may be used more frequently (lower intensity) to reduce fuel loads or less frequently to support greater vegetation structure.

Interactions – animal production, profitability, land condition and water quality outcomes

Expenditure on fencing, off-stream watering and using more regular wet season spelling and lower stocking rates are likely to reduce profitability in the short term but in the long-term land condition will improve and impacts on water quality will be positive.

Toolbox

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- 'What is a wetland?'
- 'Wetland values and ecosystem services?'

- ‘Wetlands as grazing lands’
- ‘Managing stock access and grazing in coastal wetlands’
- ‘Managing fire in coastal wetlands’
- ‘Managing weeds in coastal wetlands’
- ‘Monitoring and assessing coastal wetlands’

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Chapter 10. Reducing grazing pressure in selectively grazed areas

Selective grazing occurs at all scales but is most apparent at the land type (hectares to square kilometres) and patch scales (square metres to hectares). Paddocks are rarely uniform and different parts vary in their attractiveness to animals. Since all grazing is selective this variation in attractiveness can result in variable levels of use of different land types within a paddock. Some land types are more attractive to stock than others e.g. black basalt land type is selectively grazed over adjacent land types. Even in paddocks where overall utilisation levels are satisfactory this selective use can lead to overgrazed parts. Within a land type, patches with different levels of use can also arise from the effects of past grazing on the pastures.

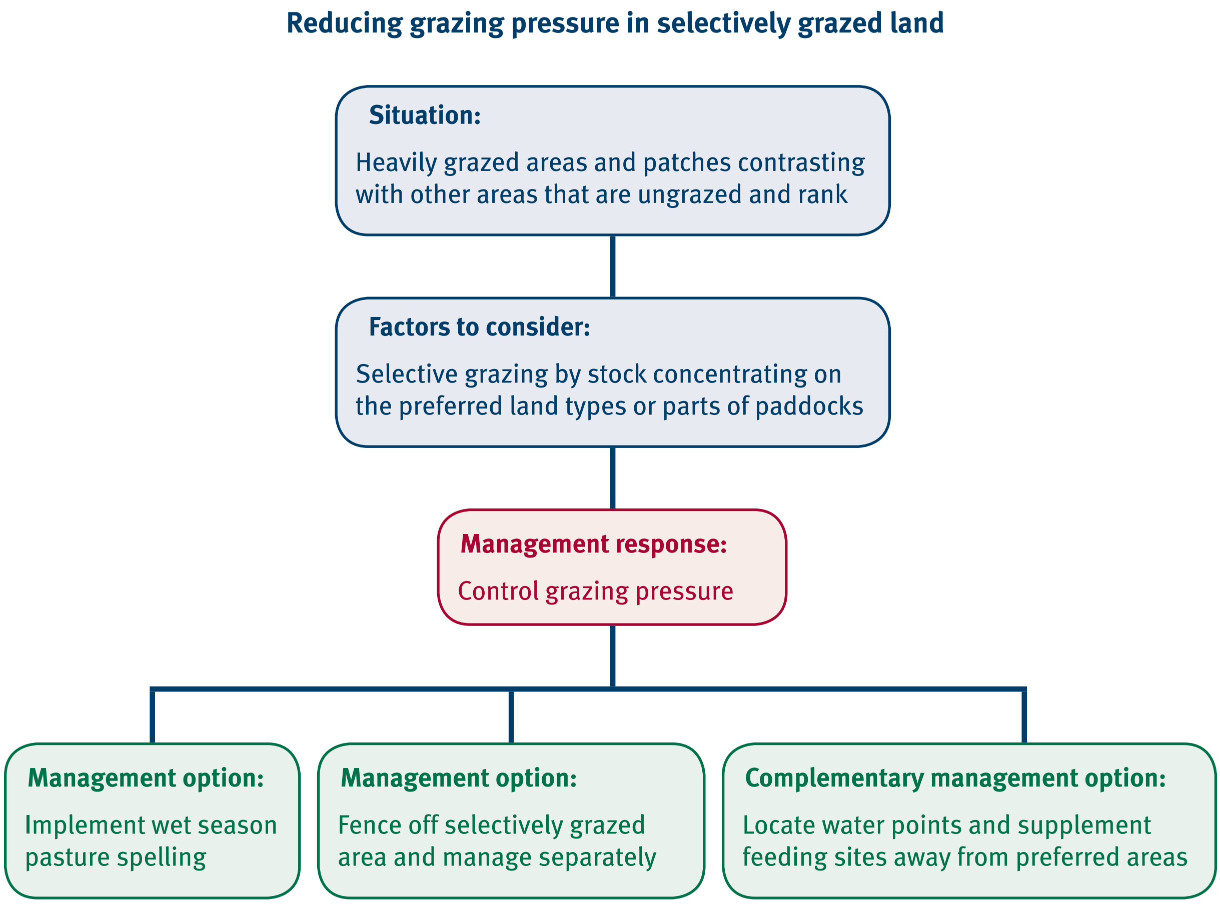


Figure 11. Diagram showing how this chapter on reducing grazing pressure in selectively grazed areas is structured.

Selectively grazed patches can occur in land in overall A and B condition (Chapter 6) but they are much more common in land in C condition (Chapter 7) and much of the information presented in those chapters is relevant here.

Situation

Paddocks where selective grazing is occurring have heavily grazed areas and patches contrasting with other areas which are ungrazed and where the pasture has become rank. The patches and ungrazed areas vary in species composition, morphology, structure and availability of forage.

Factors to consider

At the land type scale, variation in forage quantity and quality is a function of growing conditions (water and nutrient supply, aspect and temperature) and past and current grazing. Past grazing may have modified the plants present and their characteristics and current grazing will determine available forage. Animals graze more at locations with abundant quantities of preferred forage. When grazing is concentrated on particular patches or land types, forage yields and ground cover are reduced, with subsequent increases in run-off and soil movement.

In addition to differences in available forage, distance to water is an important determinant of grazing distribution with use declining with increasing distance from water (refer to Chapter 11). Animals prefer gentle slopes and seek shelter from extremes of heat and cold so differences in temperatures and availability of shelter within paddock may constrain where animals graze.

Even where there are no obvious differences in land types, patches may reflect different grazing use in the past and growth responses to dung and urine. Animals avoid low quality forage and select high quality patches and may regraze these preferred patches. Over time this continued grazing favours grazing resistant species.

Management response: Control grazing pressure

Goal: to minimise differences in grazing pressure on different land types.

Since the cause of patch development is selective grazing, management needs to prevent this to stop patch development.

Management needs to assess how grazing pressure can be adjusted to reduce overgrazing in areas of a paddock. Refer to ‘Key tools for decision making’ in Chapter 5 for information on monitoring (combined with record keeping) and forage budgeting to help determine suitable stocking rates.

Management option: Implement wet season pasture spelling

Where fencing to land type is not practical, wet season pasture spelling can help reduce the selective grazing of particular land types or patches. Fire can be used to alter the relative attractiveness of different land types and patches to animals and hence the way they utilise a paddock.

Evidence, Implementation, considerations and caveats

By preventing grazing of preferred patches during the growing season, spelling allows these areas to grow along with the non-preferred areas and hence be more similar in quality and attractiveness to animals. When animals are returned to the spelled paddocks after the wet season, grazing will be more widely distributed. However, the accumulated material will have a lower quality than if grazing had occurred during the growing season.

Burning can also be used to move grazing pressure from overgrazed patches to areas with little or no grazing. Burning the unutilised herbage on ungrazed areas makes the new growth readily available and attractive to animals and preferable to the patches that were previously being grazed. Combining burning with wet season spelling both evens out the paddock and distributes grazing more widely and gives the previously heavily grazed patches a chance to grow, develop a leaf canopy, restore root reserves and to set seed before they are grazed again.

Where water supply is controlled and overgrazed areas of a paddock are near a water point, it may be possible to spell these areas by preventing access to water and forcing animals to graze elsewhere.

Further information on evidence, implementation, considerations and caveats of wet season spelling and burning has been presented earlier in Chapter 7.

Complementary management option: Locate water points and supplement feeding sites away from preferred areas

Animals congregate at water points and supplement feeding sites and grazing pressure in nearby areas if frequently higher than in more distant parts of a paddock.

Evidence, Implementation, considerations and caveats

Where water points or supplement feeding areas are on or near to preferred land types animals are likely to graze these preferred land types more than they would if the land types were further away. Hence it seems reasonable to place water points and supplement areas away from preferred land types (if this is possible). However, the effectiveness of such placement has not been tested in the Burdekin catchment.

Complementary management option: Fence off selectively grazed area and manage separately

Fencing is the most effective but not necessarily the most practical or cost-effective way to manage selective grazing.

Evidence, Implementation, considerations and caveats

Arranging fencing so that only one land type occurs in each paddock allows a manager to control the grazing pressure on each land type. However, it can be expensive and is most suited to areas where individual land types occupy considerable areas. Where the areas of each land type are small and intermingled, fencing is unlikely to be practical. Fencing to land type can prevent the deleterious effects of selective grazing but it can also reduce the quality of the diet selected animals when they are confined to one land type rather than being able to graze a number of land types.

Interactions – animal production, profitability, land condition and water quality outcomes

In the short term there will be small decreases in animal production and financial returns as a result of the spelling and fire regimes but this management should be looked on as insurance against land declining in condition. There should be little impact on water quality in the short term but long-term benefits include prevention of escalating sediment loss.

Toolbox

Department of Environment and Heritage Protection, *ReefWise Farming*, State of Queensland (Department of Environment and Heritage Protection), ‹www.reefwisefarming.qld.gov.au/›

Future Beef website ‹www.futurebeef.com.au›.

Karfs, R, Holloway, C, Pritchard, K & Resing, J 2009, *Land condition photo standards for the Burdekin Dry Tropics Rangelands: a guide for practitioners*. Burdekin Solutions Ltd & State of Queensland (Department of Primary Industries and Fisheries), Townsville

Chapter 11. Locating water points to even out grazing

Where large (>3000 ha) paddocks still exist in the Burdekin, areas of ungrazed palatable forage can occur. This pasture represents livestock production forgone by the pastoral business while areas near water often become degraded through overgrazing. Using this ungrazed pasture can potentially increase returns by allowing more cattle to be carried where paddocks are currently stocked below the carrying capacity. Improvements in individual livestock production however are unlikely.

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 accumulation of old forage and improve grazing distribution) and spelling may aid the recovery of previously overgrazed areas.

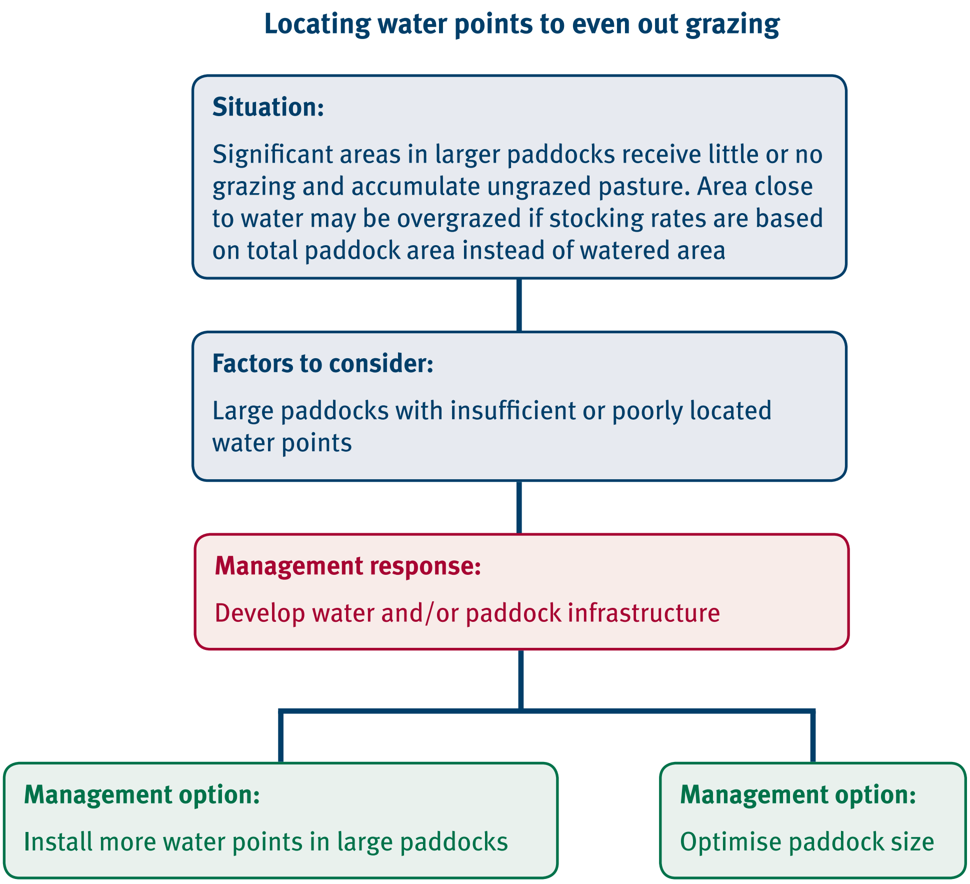


Figure 12. Diagram showing how this chapter on locating watering points to even out grazing is structured

Situation

In large paddocks – or paddocks with suboptimal paddock and water design – significant areas of the paddock that contain palatable forage receive little or no grazing and accumulate masses of ungrazed herbage. In contrast, the areas near the water points that are subject to very high utilisation are likely to have reduced ground cover and increased risk of erosion. These areas of high utilisation could be expanding quickly.

Factors to consider

Suboptimal paddock and water design are generally the main contributors to ungrazed pasture. The problem of ungrazed areas distant from water principally arises in large paddocks with few water points where animals are unable to reach the distant parts of the paddock during daily foraging activities. Cattle need to drink regularly (usually once a day) under the hot conditions experienced in northern Australia. Studies in the Desert Uplands (Jones and Aisthorpe, pers. comm.) showed that 90% of grazing occurred within 3 km of a watering point. Local knowledge suggests there are few areas within the Burdekin that are beyond 3 km to water and this issue has been largely addressed by industry. 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 (e.g. black basalt country) can also contribute to this problem.

If stocking rates for a paddock are based on paddock size but not all of the paddock is close to water points, there will be an excessive number of cattle congregating around existing water points. This will contribute to the development of large, expanding areas of overgrazing and land degradation around water points, promoting soil loss and weed invasion.

Uneven grazing patterns are often associated with:

- inadequate number and/or location of water points in relation to paddock size
- avoidance of land types with less palatable pastures or limited accessibility
- concentration of grazing on preferred land types, plant species or based on soil type
- tendency for livestock to revisit previously grazed patches to consume nutritious regrowth (patch grazing)
- landscape features (riparian zones, hills, ranges, roads, creeks)
- wind direction or other persistent weather conditions
- location of feed supplements at watering points
- fire (especially when patchy)
- behavioural characteristics of different animals.

Management response: Develop water point and paddock infrastructure

Goal: to sustainably use the herbage grown in a paddock.

The most important management response is to make the areas of palatable forage accessible to cattle (i.e. all areas are within walking distance of water for the cattle) by establishing more water points.

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

It should be acknowledged that more infrastructure is not a substitute for good land management. However, more infrastructure usually requires a higher level of management to make the best use of it. Fencing provides the ability to apply special management to environmentally sensitive areas (e.g. frontage/

riparian/wetlands/springs and softwood scrubs) although costs can be high as these areas are often relatively small. Smaller paddocks provide greater flexibility to use wet season spelling.

Factors to consider before spending money on infrastructure include:

- adequacy of stock water distribution
- number and area of current paddocks
- cost/benefit of additional fences and waters including ongoing maintenance and running costs
- priority land type to manage (i.e. most productive)
- complexity of land types within existing paddocks
- possible reduction in diet selection due to restriction of access to a range of land types throughout the year
- likelihood of obtaining an increase in production to cover the extra capital investment
- terrain and its ease of mustering
- area of each land type within each paddock and whether each will carry sufficient cattle to make it worth subdividing e.g. subdivision into smaller paddocks may be suitable if near the house or yards, but in the remote parts of the property, land types would need to be capable of sustainably running at least 100 head (less for smaller properties) to warrant land type fencing.

Management option: 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. The distance from water to palatable forage should not generally exceed 3 km. Thus, to ensure reasonable levels of use of an entire large paddock water points should not be separated by more than about 5-6 km. A good rule of thumb is to allow one water point per 2000–2500 ha (20–25 km^2) of land area.

Evidence

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

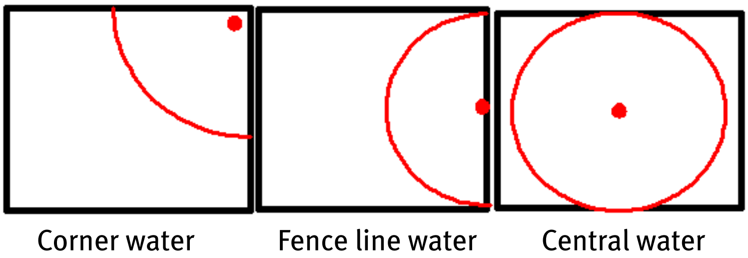
Although a number of studies have reported the maximum distance cattle will walk from water to forage in northern Australia (e.g. up to 11 km on the Barkly Tableland and usually no further than 5-8 km in central Australia), most grazing by cattle occurs much closer to water. Grazing pressure usually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

In the Pigeon Hole project in the Northern Territory where additional waters were established in a large paddock, approximately 90% of cattle activity (assessed using GPS cattle collars) occurred within 3 km of water (Hunt *et al.* 2010). This was because a large proportion of the paddock was within 3 km of water and there were smaller areas beyond this distance (the average distance to water in this paddock was 2.1 km). As a result there were fewer areas where ungrazed forage accumulated. Establishing new water points in large paddocks at Pigeon Hole allowed more cattle to be carried because more of the country was accessible for grazing.

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

Although these research findings are relatively new, Burdekin graziers recognised the need for extra watering points in the early 1900s when dams were built with scoops and bores were drilled to provide stock water in areas remote from permanent waters in streams and springs.

Table 7. Example of the impact of water point placement on effective grazing area and stocking rate.



	Corner water	Fence line water	Central water
Total paddock area (ha)	5 000	5 000	5 000
Number of head in paddock (8 ha/head)	625	625	625
Area within 5km of water (ha)	707	1413	2826
Stocking rate within 3 km of water (ha/head)	1.1	2.3	4.5

Implementation

Site water points on reasonably level ground away from:

- **fence lines**. Studies in semi-arid rangelands in SA and WA have shown that grazing use within paddocks is more evenly distributed if water points are located away from fences. Although corner and paddock boundary locations for waters are preferred from a cost perspective, they create problems because they concentrate cattle in a smaller area and increase the effective stocking rate close to water (Table 7). This creates larger sacrifice areas around the water and can negatively impact on production because animals need to walk further to access feed. A centrally located water point dramatically increases the watered area of the paddock and results in lower effective stocking rates within 3 km of water.
- **areas that cattle favour** (e.g. creek lines, riparian areas, black basalt country) whenever possible as this may help in reducing the extent to which cattle congregate around the water for lengthy periods and reduce the possibility these areas will be overgrazed.
- **sensitive parts of the landscape**, such as highly erodible soils
- **drainage lines, concentrated flows, or depressions**.

Considerations and caveats

There will be regional differences in how many water points are needed and how far apart they should be placed. In the Burdekin more productive land types may have already developed their optimal number of watering points. However, the mix of land types and other management considerations also influence the decision to increase the number of water points.

The cost of developing new water points must be considered. Where installing new water points ‘opens up’ new country to grazing, the investment is more likely to be worthwhile. The quality of the land in ungrazed areas should also be considered prior to installing additional water points. Some land may be ungrazed because of low value pastures rather than because it is too far from water and installing a new water point to make this area more readily accessible to cattle may not be financially worthwhile. In a paddock that has multiple water points cattle will not necessarily distribute themselves evenly amongst the different waters. In very large paddocks carrying many animals this can result in large congregations of cattle on certain water points. The number of animals using a water point should be limited to approximately 300 head (McIvor *et al*. 2010). Graziers recommend two troughs per watering point.

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

Shutting off all or the majority of man-made waters during the wet season in a paddock where there are no natural water points, creates a wet season spelling regime without the need for additional fencing. The construction of dams in large paddocks that contain steep range country provides the opportunity to close off waters on the flatter country during the wet. This will force cattle to graze the ranges thus inducing a wet season spell on the lower sloping areas that are often overgrazed and exhibit poor land condition. Waters on the flatter areas are opened up during the dry season to make the whole paddock available for grazing.

If dams are the chosen option for extra waters, fence the storage area to permanently exclude stock and use windmills or solar pumps to reticulate water to a tank and trough. Although this is an expensive exercise, it provides the opportunity to reticulate water to several new watering points from the one water source using poly pipe. It also ensures that drinking water quality is high, even during droughts when water levels in dams are low.

If fire is used to remove old feed careful management is required after burning. It is generally considered important that 3P grasses in burnt areas be allowed to re-establish so there is a reasonable body of feed before they are grazed again after burning. Burnt areas are best rested from grazing for an entire growing season before being grazed again. Burning in the early dry season will effectively mean the paddock cannot be used for the remainder of the dry season since the cattle will concentrate on these areas and potentially kill the regrowing 3P grasses.

Spelling may also be required to allow the recovery of overgrazed areas once new water points are established (refer to Chapter 7).

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

GLM workshops have typically recommended water points be placed 5-6 km apart based on marginal gains in carrying capacity. This evidence has been based on earlier NT research and may require adjusting (refer to Chilcott *et al*. 2000).

Water point placement should also take into account the value of water-remote areas for biodiversity conservation (Landsberg *et al*. 1997; James *et al*. 1999).

Management option: Optimise paddock size

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

Evidence

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

There is limited evidence from formal research on the effect of paddock size on grazing distribution and pasture use. The Pigeon Hole project in the Victoria River District (VRD) of the Northern Territory is the only project to have specifically investigated the effect of different paddock sizes (Hunt *et al*. 2010). Using GPS collars to record cattle distribution in paddocks, the research indicated that individual cattle (and the mob as a whole) generally used a greater proportion of a paddock if paddock size was reduced. Confining cattle to smaller paddocks appears to have some effect in 'forcing' them to use areas they may not use if paddocks were larger (although they still may not use areas that contain few palatable plants). This effect means that having more, smaller paddocks results in grazing being distributed more widely across the landscape as a whole and should improve the effective use of available forage.

It is also obvious that fences control where cattle can go at the landscape scale, thus preventing too many animals congregating on preferred parts of the landscape. However, the research also showed that reducing paddock size did not substantially improve the uniformity of grazing at smaller scales (e.g. patch scales) within paddocks and where this is a problem management options other than paddock size need to be used (refer to Chapter 10).

Reducing paddock size to that approximating 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 the more extensive regions as it will mean most areas in a paddock are accessible to cattle. Assuming a grazing radius of 3 km this would translate to a paddock size of about 3600 ha (36 km^2). In paddocks of this size at Pigeon Hole the herd generally used 80% or more of the paddock area compared to approximately 70% in larger paddocks where additional watering points had been established. This suggests there is little value in reducing paddock size below that where all parts are accessible to cattle (i.e. 3000-4000 ha, 30–40 km^2) in the more extensive regions of northern Australia, from the perspective of improving grazing distribution. There are unlikely to be increases in total livestock production as a result of further reductions in paddock size.

Suitable paddock size varies between regions. A study of grazing patterns in smaller paddocks (500–2000 ha) typical of the Burdekin found that the level of pasture defoliation varied little up to 2 km from water (McIvor *et al*. 2010). The small paddock size is likely to have contributed to evening out grazing, although other environmental factors such as the location and mix of more productive land types would also have been important. This evidence suggests that paddocks of 1500–2000 ha (15-20 km^2) might be appropriate for the Burdekin region (although there are no readily available data on grazing patterns for larger paddocks in this region).

Implementation

- Subdivide large paddocks into areas of approximately 3000–4000 ha.
- To allow better management of grazing impacts, paddocks should be designed to separate minor land types that are sensitive to grazing (e.g. riparian zones, frontage country) and exclude gullied areas wherever possible.
- Paddocks that contain relatively uniform land types and pasture are likely to be grazed more uniformly. In many situations this will not be practical due to relatively small size or irregular shapes of such areas.

- An understanding of how cattle use the landscape (e.g. their tendency to avoid steep or rugged country) should be used to inform paddock design.
- Creating smaller paddocks will often require the establishment of additional water points to provide water in all paddocks. Where possible, it is recommended that the smaller paddocks contain at least two water points (particularly if they are around 3000-4000 ha, 30-40 km^2). This would further increase the extent of the area grazed in paddocks, reduce the potential for excessive overgrazing around water points (by reducing the number of cattle per water point) and provide some safety and flexibility should one water point fail. Allowing at least one water point per 2000-2500 ha is recommended to ensure all areas are accessible to cattle.

Considerations and caveats

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

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

Smaller paddocks do not result in completely even use within a paddock. Some areas may still not receive much use and some areas will be heavily used. However, the rate at which overgrazed areas grow will be slower. As well as reducing paddock size, the use of other tools such as the strategic placement of supplements or prescribed fire should also be considered to improve grazing distribution in paddocks (refer to Chapter 11).

There may be a role to use more supplement points or move the existing ones around the under-grazed areas to encourage utilisation of dry rank material during the dry season and take the pressure off existing patches. Semi-permanent electric fences can be used to give patches a spell for a shorter period of time.

Fencing of new paddock areas should also take into account the value of water-remote areas for biodiversity conservation (Landsberg *et al.* 1997; James *et al.* 1999).

Interactions - animal production, profitability, land condition and water quality outcomes

Utilising previously uneaten feed will increase carrying capacity and animal production. The effect on financial returns will depend on the balance between the cost of development and the extra animal returns. Land condition around previously heavily used water points will improve with positive results for water quality. Provided the newly grazed areas are not overgrazed they should remain in good condition with no water quality issues. Even where water quality improvement can be expected, because of the considerable economic and labour costs, fencing is not considered a least cost option for water quality management.

Toolbox

Peck, G 2006, *Property planning: Using off-stream watering points*, Fitzroy Basin Association, Rockhampton.

For current DAFF workshops please refer to the Future Beef website ‹www.futurebeef.com.au›.

Chapter 12. Minimising erosion when locating infrastructure

Roads, tracks and fences are essential for property management but if inappropriately located or poorly constructed they can cause problems. When siting and constructing infrastructure it is important to avoid concentrating water and if necessary adequate drainage should be provided to dispose of water safely. Some soils are prone to erosion and if possible these should be avoided when locating infrastructure.

Note that approvals and permits may be required for locating and establishing stock water dams.

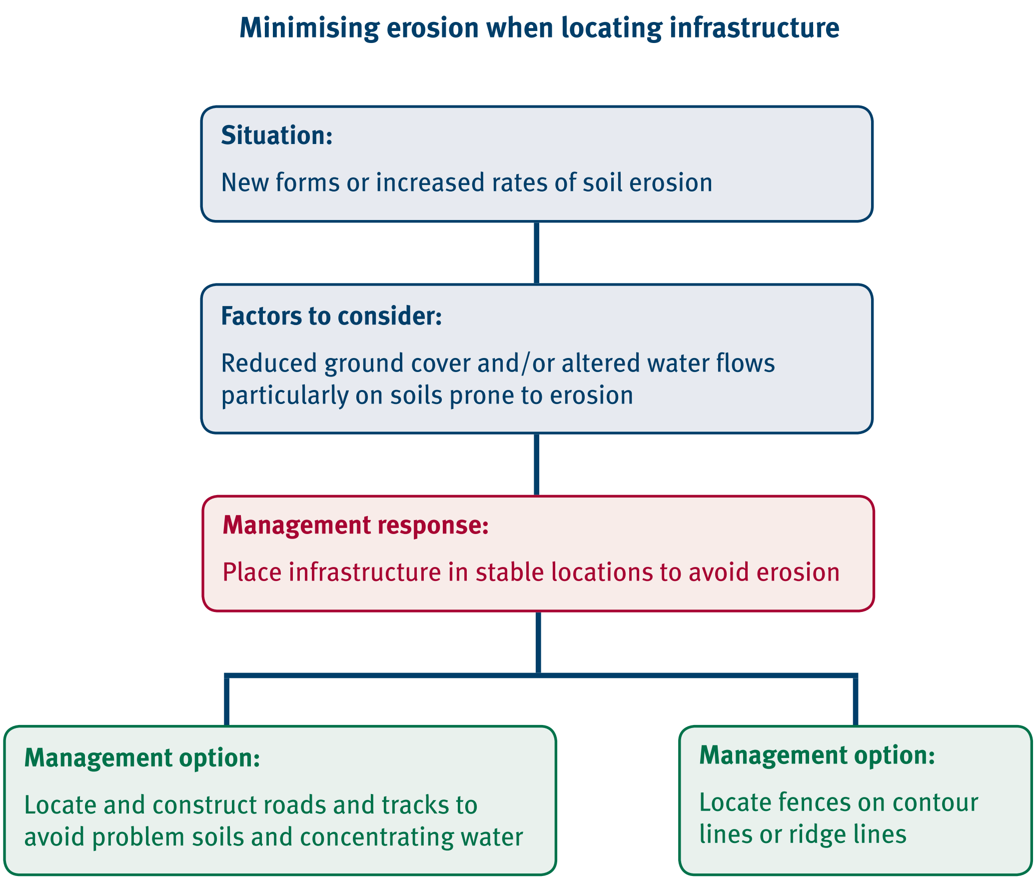


Figure 13. Diagram showing how this chapter on minimising erosion when locating infrastructure is structured.

Situation

The first signs of inappropriately located or constructed infrastructure may be new forms or increased rates of soil erosion.

Factors to consider

Erosion is a symptom of a set of circumstances that have not been managed well. The cause may be the poor location of a road or fence or overgrazing by livestock. If the problem already exists then the first step is to confirm the cause. If the cause if identified as management, then determine how current practices are contributing to the problem and plan for some appropriate change.

Infrastructure can impact on erosion by reducing ground cover and/or altering water flows and these issues are compounded if the water flow occurs on soils susceptible to erosion. Features of soils prone to erosion include:

- Little or no soil structure
- High silt and fine sand content
- Low organic matter
- Low permeability to water
- High dispersability (soil fragments collapse rapidly when wet and form a slurry)
- Surface crusting and hardsetting.

Sodic duplex soils are widespread in the Burdekin catchment and are particular soil erosion hazards. Many have surface soils that are shallow and structureless or weakly structured, water infiltration is often low and the subsoils have low permeability and high dispersibility due to high levels of exchangeable sodium. The subsoil is therefore very erodible if exposed to rainfall or surface flow.

Management response: Place infrastructure in stable locations to avoid erosion

Goal: to avoid infrastructure causing erosion.

Some erosion sites are along man-made structures such as a road, pipeline, fence, or water point.

Management option: Locate and construct roads and tracks to avoid problem soils and concentrating water

It is usually easier and cheaper to avoid a problem arising than to have to undertake expensive and difficult repairs to fix up a problem later so planning is an essential first step. Infrastructure is expensive and should be designed to last for decades so it is necessary to consider long-term requirements.

Evidence

Access roads and tracks can concentrate and divert runoff within a property. If they are well designed, constructed and maintained the effects can be minimised, otherwise soil erosion and sediment contamination of waterways can result. Whatever the size and complexity of the road or track, the management principles are to minimise exposed earth and to avoid concentrating and channelling the flow of water.

Factors determining the contribution of sediment from roads to waterways are:

- The level of connectivity between table drains and the waterways. Lowering connectivity requires that either water is discharged from table drains and spread across vegetated landscapes where sediment can settle, or that the flow is directed into detention basins for sediment settling.
- The amount of disruption of road surfaces by traffic.
- Soil types where roads are constructed and the type of gravel used.
- The type of vegetative cover and profile of table drains.

Studies also indicate that the majority of sediment from roads entering streams is often contributed by only a small fraction of the road network.

Implementation

- Where possible locate roads in areas with little slope and away from wet areas, gullies, and creeks.
- Roads on ridges and crests will shed water minimising water pooling on them.

- When crossing slopes, roads should be sited as near to the contour as possible. Construct roads and tracks across slopes with sufficient camber for drainage but to still allow the safe movement of traffic.
- Roads should cross watercourses at rocky or gravelly areas and if possible the roads should enter streams at an angle rather than directly up and down the bank. Note approvals may be required for the construction of waterway crossings.
- During the construction of roads, disturbance to soil and vegetation should be minimised although it will not be possible to totally avoid some disturbance.
- Construct stormwater drains with flat bottoms rather than vees to minimise erosion.
- Locate roads and tracks in areas where soils are stable in order to minimise erosion.
- If roads are not formed up, install whoa boys (i.e. speed bumps, traffic calmers) at intervals of 20 to 200 metres depending on slope and soil type and ensure stormwater is discharged into a detention basin in to a stable, well grassed area.
- Additional constructions may be required on steeper embankments. e.g. whoa boys, diversion banks. Avoid creating tracks in waterways and outlets of diversion banks and by-washes of dams.
- Avoid constructing roads and tracks that redirect overland flows and runoff water. Design for the free and continuous runoff flow across roads and tracks. Include inverts or pipes of an adequate size to handle the run-off.
- On flood prone land, construct roads and tracks at the same level as the land on both sides and gravel the surface. Wide inverts are recommended across natural water flow lines.
- Ensure that upslope table drains are shallow and broad.
- Ensure there are well grassed table drains at both sides of the road or track. Where pipes and inverts are required, discharge must be towards a stable area.
- Avoid locating gateways in depressions or in sites prone to seasonal waterlogging where water drains or is likely to concentrate.

Considerations and caveats

There may be only limited locations for placing infrastructure and if sensitive areas cannot be avoided it may be necessary to use engineering solutions to overcome problems e.g. low banks (whoa-boys) across roads to divert water, table drains where required, floodways, causeways culverts or bridges for creeks.

Management option: Locate fences on contour lines or ridge lines

Fences, as with tracks and roads, require removal of tree and shrub cover for construction (although pasture cover can be retained by keeping the dozer blade above the ground). This results in increased runoff, leaving the soil surface vulnerable to accelerated erosion. For erosion control, the location of fence lines should follow the same principles as those applied to roads and tracks. The most suitable alignments are those along ridgelines or parallel to the contour lines and in areas of good drainage. If possible, avoid constructing fences on highly erosive soils.

Evidence

Fences should follow contour lines or be located on ridges if possible to avoid cattle making tracks up and down slopes when following a fence line.

Implementation

- Identify the area to be fenced on maps or aerial photos. Draw a tentative location of the new fence line and inspect areas which may cause problems (e.g. drainage lines) and relocate if necessary.
- Locate fence lines where possible along ridgelines or parallel to the contour. Avoid alignments which run diagonally across the slope.
- Existing fences not in ideal positions should be scheduled for relocation or upgrading in the long-term work plan.

- Natural barriers such as rivers should be used to supplement fences.
- Plan ahead for the strategic location of gates and the need for erosion control banks.
- Maintenance requirements and the need for machinery access should be decided at the planning stage before construction begins.

Considerations and caveats

In many situations fence lines can be constructed with minimal disturbance to the soil surface.

Badly eroded fence lines are rarely stock-proof and make access more difficult and use valuable resources in repair work.

Interactions – animal production, profitability, land condition and water quality outcomes

Infrastructure per se will not affect animal production but is essential to be able to manage a property. Where infrastructure is appropriately located and constructed it can make large improvements in water quality as problems are avoided or remedied.

Toolbox

Department of Environment and Resource Management 2010, *Erosion control on property roads and tracks: cross sections and locations L239, Erosion control on property roads and tracks: Managing runoff L240 and Erosion control on fences and fire breaks L241*, State of Queensland (Department of Environment and Resource Management).

Department of Environment and Resource Management 2011, *Soil conservation waterways – Construction and management L270, Soil conservation waterways – Plants for stabilisation L271 and Soil conservation waterways – Planning and design L272*, State of Queensland (Department of Environment and Resource Management).

Hadden, K 1993, *Soil Conservation Handbook for Parks & Reserves in the Northern Territory*, Conservation Commission of the Northern Territory, Darwin.

Natural Resources and Water 2006, *Erosion control in grazing lands L91*, Sate of Queensland (Department of Natural Resources and Water).

SEQ catchments, *Roads and tracks*, Department of the Environment, Water, Heritage and the Arts.

For current DAFF workshops please refer to the Future Beef website ‹www.futurebeef.com.au›.

Chapter 13. Minimising woody plant problems

Burdekin grazing lands comprise a wide range of vegetation communities but most include some woody species, both trees and shrubs. Naturally-wooded communities in good condition may vary in tree and shrub density and diversity but if pasture condition of wooded communities deteriorates, tree and shrub cover may increase, leading to woody thickening and loss of pasture grasses. More open land types in the Burdekin – such as downs country – are prone to encroachment by woody plants, also known as woody plant invasion.

Minimising woody plant problems

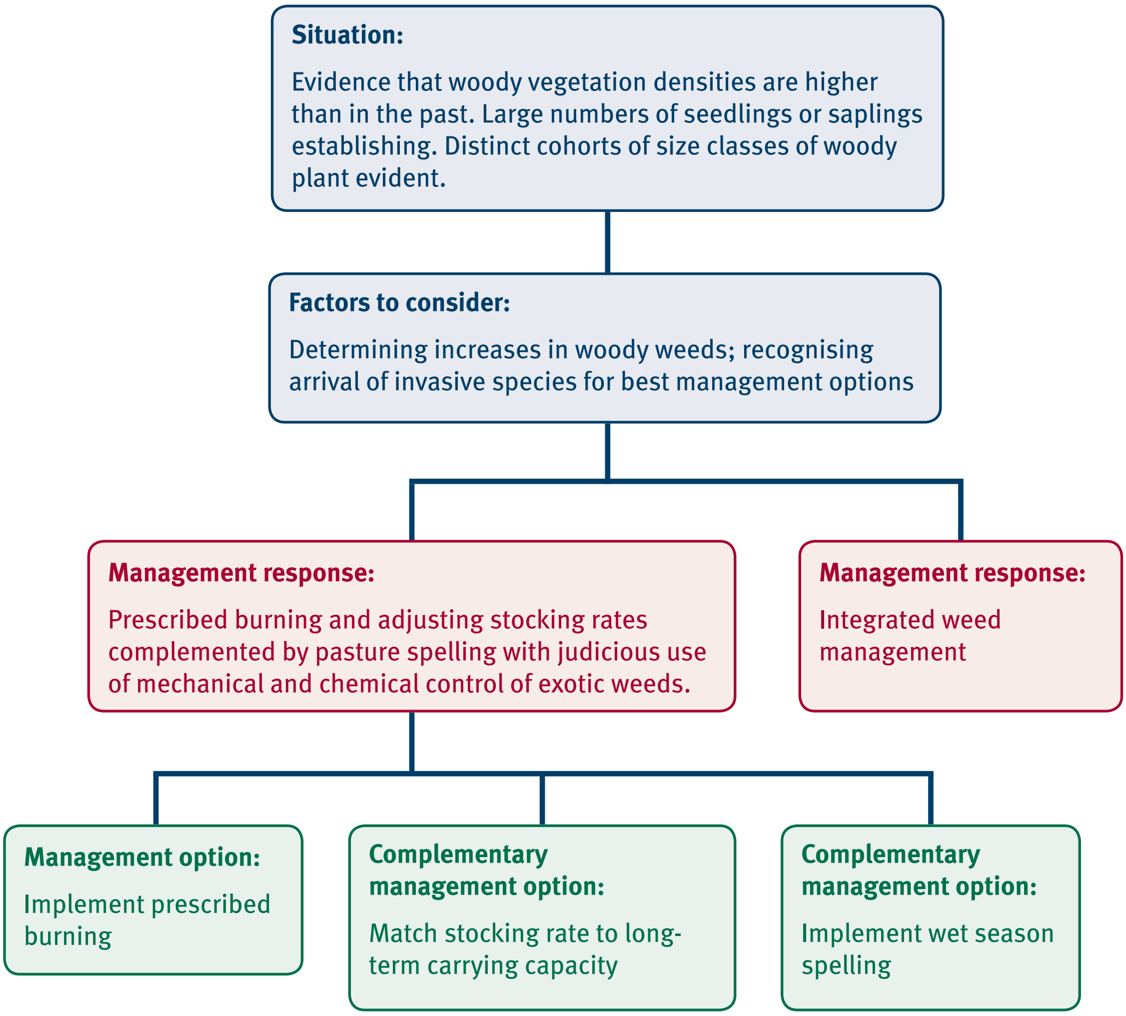


Figure 14. Diagram showing how this chapter minimizing woody plant problems is structured.

Trees and shrubs appear to have become more prominent in some communities under pastoral management. This increase comes from three sources:

- thickening of native understorey species
- thickening of native upper storey species
- invasion by non-native trees, shrubs, and woody vines.

Woody thickening or encroachment may involve different species in different locations and often involves multiple species. Species differ in their growth form, mode of reproduction and reproductive output, mode of dispersal, recruitment patterns, and longevity, and their responses to different types of disturbance. They also differ in how palatable they are to cattle and other grazing animals. Any kind of shoot damage, caused by browsing, clearing, or fire, will influence different species, or even different individuals of a species, in different ways. Heat from fires or scouring of soil by machinery can also stimulate the germination of seeds of some woody plants.

Why is the proliferation of native or non-native woody species a problem in pastoral lands? The following are the major issues, though their absolute and relative importance varies from one situation to another:

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

The relationship between woody and pasture plants is a critical one. In general, as woody plant biomass increases, pasture biomass decreases. 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. Tree thickening or encroachment is not always problematic. At medium tree densities, silver-leaved ironbark did not reduce pasture growth at Anakie in the Fitzroy catchment (Silcock *et al*. 2005).

Also, some species of woody plants, native and non-native, can provide both useful browse which may contribute significantly to livestock diets and shade for cattle as well as habitat for native animals. In particular, trees and shrubs are a natural and important part of riparian areas and certain ecosystems consisting of a diverse assemblage of upper-, mid- and lower-storey plants that should be maintained.

In Queensland, the restrictions that apply to mechanical clearing of vegetation also apply to the use of fire for the same purpose. Moreover, tree and shrub cover is an important part of the carbon stores on a grazing property and management to maximise carbon stores may become important on cattle properties.

A number of problem trees, shrubs and woody vines are exotic species and some are listed weeds that the landholder is obliged to control.

Situation

Increasing native trees and shrubs has reduced land condition

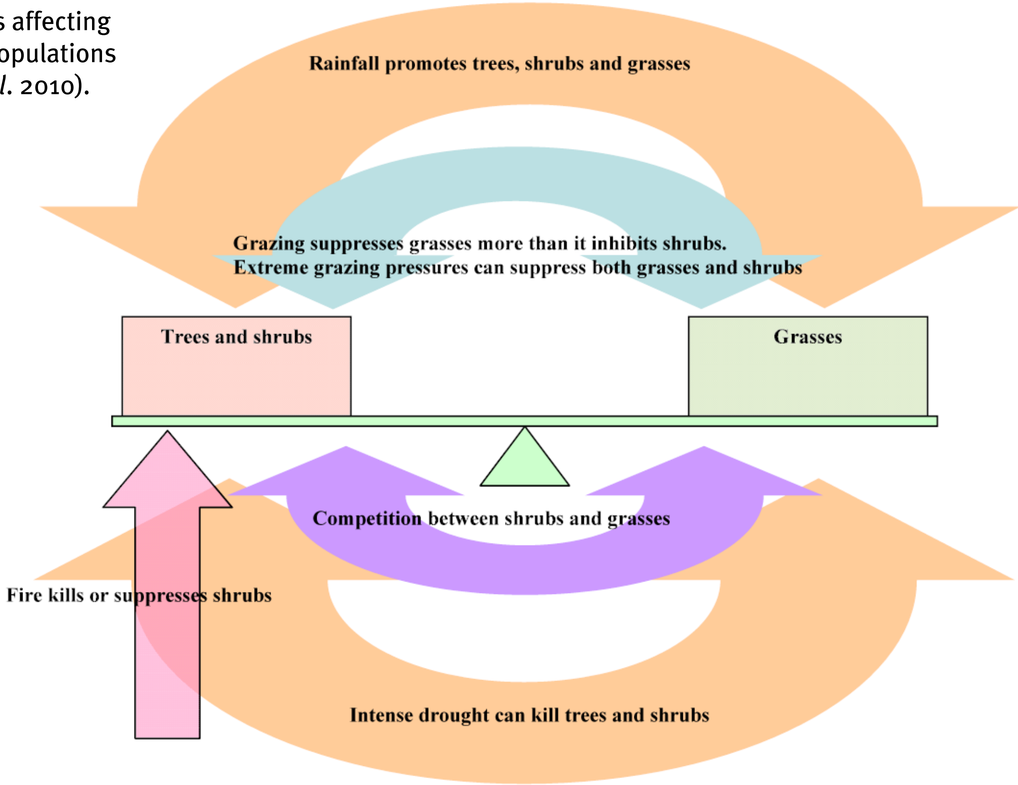
In a healthy environment, woody and pasture (mainly grasses) components of the vegetation are maintained in a dynamic balance by the following factors (Figure 15):

- rainfall as a promoter of germination and growth
- drought as a cause of mortality
- competition between grasses and woody species (for water, light and/or nutrients)
- grazing and browsing differentially affecting yield and possibly survival
- fire as a remover of pasture yield and a cause of top-kill and mortality of woody species.

The significance of these factors is likely to vary from place to place.

Under deteriorating land condition, this balance may be shifted, leading to an increase in native woody plants. This may result from overgrazing, a poorly planned fire regime or a combination of the two. Not only does overgrazing reduce competition from grasses, but it reduces fuel loads needed for fire hot enough to top-kill woody plants. Woody plant cover also varies with climate cycles, increasing in wet periods and decreasing in

Figure 15. Factors affecting tree and shrub populations (from McIvor *et al.* 2010).



drought and may be promoted by increasing atmospheric carbon dioxide concentrations.

Grazing

Cattle and other grazing animals select the most palatable plants; cattle prefer 3P grasses. These grasses have a variable ability to tolerate removal of top-growth through the year. If grazed too hard, they lose vigour and, with further grazing, may die. Among the less palatable species that will take over are a number of woody plants that can shade-out palatable grasses altogether. This is why restricting grazing to recommended utilisation levels is so important. 3P grasses are particularly sensitive to overgrazing early in their growth cycle when they are first resprouting after rain.

Fire

Just as overgrazing weakens 3P grasses to the advantage of woody plants, so can inappropriate burning. Perennial grasses should never be burnt through the mid- to late-wet season (Smith 1960). Fire can also intensify the impact of grazing, as animals are attracted to the nutritious green-pick that resprouts after fire.

Many woody plants have the ability to re-sprout following burning. Poplar box, silver-leaved ironbark, narrow-leaved ironbark, sandalwood, brigalow, currant bush, and most wattles re-sprout from growing points on the stems, lignotuber or roots. Sally wattle and brigalow regrow prolifically from root suckers and seem to have little regeneration from seed. Hickory wattle, yellow wattle, and black wattle also sucker after fire.

Burning may encourage the germination of hard-seeded plants, especially wattles such as lancewood, hickory wattle, yellow wattle, and black wattle. In balance or in small patches, these plants are an important part of the grazing system, contributing nitrogen to the soil. However, when fires are wide-spread or lit at a time that disadvantages grasses, they may become a problem.

Fire is a natural part of the landscape. If used well, as part of good grazing practices, fire can help to maintain both healthy vegetation communities and productive pastures and be an effective tool to manage woody plants. However, there are also times when fire is likely to cause loss of pastures, exposing the soil to erosion and cause unnecessary damage to riparian and other sensitive vegetation.

Invasion by woody exotic weeds

Exotic woody weeds may be dispersed by wind or birds, in the coats or dung of livestock, in machinery and tyres tread, or washed down rivers. Most thrive under disturbance that removes competition. Invasion of woody weeds therefore tends to be worst around yards, along roads and along riparian areas. The most problematic woody exotic plants in the Burdekin include rubber vine, chinee apple, and parkinsonia.

An ABARE Report about natural resource management in the Burdekin catchment concluded that '*the invasion of weed species in rangelands is closely linked to grazing management and often reflects a combination of droughts, grazing pressure and lack of fire. Prolonged grazing pressure in combination with highly variable rainfall and inadequate fire management strategies to remove weed growth has reduced ground cover and soil condition in many areas, leading to a replacement of desirable productive pastures species with weeds*' (Beare *et al.* 2003).

Factors to consider

Among the factors driving increases in populations of woody plants are:

- sequences of very wet years
- reduced competition from grasses caused by moderate to heavy grazing
- reduced frequency and/or intensity of fire because of lack of fuel or active fire suppression
- rising CO_2 levels, as suggested in some literature.

Determining whether there has been an increase in native woody vegetation is not always simple. Anecdotal indications might be that a grassy plain no longer exists, or that key landscape or infrastructure features are no longer visible at a distance. Many landholders will have specific information about which land types and species are involved and the causal processes, such as floods, fire, or overgrazing (Lankester 2006). However, perceptions may be affected by recent climatic events. As woody vegetation cover is dynamic, increases may be short-lived through wet periods and be replaced by thinning in drier periods (Fensham and Holman 1999, Bray *et al.* 2006).

Assessment using aerial photography or satellite imagery or even comparison of landscape photographs taken several years apart can verify whether thickening has occurred and to what extent. Comparison of the tree and shrub cover in photos used for photo monitoring is also a useful source of information (Lewis 2002). Long-term vegetation monitoring plots are also being used to track changes in woody vegetation cover across Queensland grazing lands (Bray *et al.* 2006).

It is essential to know which species are involved to manage them effectively. A good knowledge of native flora will help identify the arrival of new species on the property and the implementation of control measures to prevent the species becoming a problem. Good weed guides are available and familiarity with significant weeds will help to identify the best management options. Where a weed is well established, mapping and monitoring of infestations using GPS trackers will help to assess whether control measures are working.

Management response: Burning, adjusting stocking rates, pasture spelling and integrated weed management

Goal: to reduce and/or minimise the population of woody plants so there is little competition with pastures and few effects on property management.

Fire and grazing are the principal management tools that influence the woody components of northern Australian vegetation. Critically, these two management tools interact with one another (Figure 15) as herbivores and fire, in effect, compete for forage. Good grazing management described in earlier chapters will help prevent woody thickening and encroachment. Prescribed burning, however, constitutes the most effective management response to increased woodiness of northern Australian vegetation.

If detected early and managed effectively, exotic weeds can be contained or even eliminated. Fire and grazing can also be used to manage exotic woody weeds, but mechanical control and chemical treatment may also be required.

Management option: Implement prescribed burning

This will generally involve instituting a regime of burning, the most useful regime depending on the woody species present, their density and the size class structure of their populations. More intense fires may be useful for species that are more tolerant of fire, where tree and shrub densities are high and where plants are large. Less intense fires may be suitable for fire-susceptible species, sensitive ecosystems such as riparian areas or where the purpose is to reduce or suppress a cohort of recently-established (i.e. small) shrubs.

Patch burning

Evidence

Species responses

Woody species vary in their susceptibility to fire (Tables 8 and 9). Small plants, particularly seedlings are more susceptible to fire than adult plants. Plants prone to woody thickening are often fire tolerant as adults or suckers. However, they may succumb to fire at the seedling stage or if the fire is lit at a time of the year when the plants are most vulnerable. Work in the upper Burdekin woodlands and adjacent coastal areas showed that mid- to late-dry season fires killed significant proportions of rubber vine and parkinsonia populations (Grice 1997a) even with fuel loads under 2000 kg/ha (Radford *et al*. 2008). Intense fires typical of the late-dry season can also be effective at top-killing woody plants that have a high suckering rate. However, mid- to late-dry season fires also risk loss of pastures and causing significant environmental damage, including loss of wildlife habitat and soil erosion if the first rainfall after the fire is a heavy downpour.

Table 8. Native woody plants liable to vegetation thickening in the Burdekin, their susceptibility to fire, and the types of fire needed for their control.

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

Many plants may also be effectively controlled by burning after the first heavy storms in the build-up, termed a storm-burn. These burns can only be lit in the first 2 to 3 days after the first heavy downpour. This is when the soil is wet but the rank old growth has already begun to dry off; regrowth of perennial grasses has barely emerged from the ground, but the sap in woody plants has begun to flow. So intense fires can be achieved without spreading too far and perennial grasses are protected from damage, while woody plants are at their most vulnerable (Crowley *et al*. 2009).

Control of woody plants using storm-burning has been demonstrated to be effective with suckering plants such as broad-leaved ti-tree (Crowley *et al*. 2009); currant bush, which spreads by layering (Radford *et al*. 2008), as well as the exotic rubber vine (Radford *et al*. 2008).

The intensity and frequency of fire and subsequent grazing pressure can have a large impact on the response of woody species. A one-off fire may have little long-term impact on the size or total basal area of the population of woody plants, while two or more fires in a decade may have a longer lasting impact (Table 8).

Table 9. Habitat preferences of prominent woody exotic weeds of the Burdekin rangelands (after Grice *et al*. 2000, Grice 2001, ‹www.daff.qld.gov.au›).

Species	Area	Preferred habitat	Control options	Impact of fire
Chinee apple	Drier tropics, average annual rainfall of 470–1200mm. Densest areas around Charters Towers, Mingela, Ravenswood and Hughenden.	Many soil types including coarse-textured gravelly soil, deep alluvials, solodic and cracking clay soils; severely disturbed areas, especially where native trees are cleared.	Combine mechanical and herbicide treatment or use herbicides alone. Follow-up to treat regrowth treated.	Seedlings susceptible to fire. Some damage to mature plants but regrowth is normally rapid and few plants killed.
Lantana	Coastal and sub-coastal from Far North Queensland to southern New South Wales.	Wide variety of habitats ranging from dry hillsides to shaded gullies; range of soil types but does best on more fertile soils.	Exclude stock to build up fuel load and burn. Burn again in summer just before rain and spot spray lantana regrowth when › 0.5 m high and when it is actively growing. Follow-up spot treatments with chemicals. Restock only when pastures are re-established.	Up to 70% of adult plants can survive fire, but two consecutive fires will be more effective, especially where pasture recovery is strong. Fire is not recommended in fire –sensitive areas (e.g. rainforest.)
Parkinsonia	Sub-humid and semi-arid areas.	Variety of soil types but commonly on areas of heavy soils that are periodically flooded Combined chemical, mechanical, biological and fire with land management practices.	Combined chemical, mechanical, biological and fire with land management practices.	Fire will destroy seedlings with sufficient fuel. Kill rates for mature plants vary from 30% to 90% with best results obtained from slow moving fires.
Rubber vine	Wet-dry tropics where average annual rainfall 400–1400mm.	Riparian areas including along major rivers and minor creeks.	Combined chemical, mechanical, biological, and fire with land management practices.	›80% plants ‹2 m high are killed by fire. Fire after the first heavy rain opens up the plant to increase grass growth. A second fire one year later removes most plants. Care with fire is required in fire-sensitive riparian vegetation (Box 1).

Box 1. Conditions required for effective rubber vine control:

- Accumulated dry fuel around the base of rubber vine plants, such as a season of ungrazed, rank grass or flood debris along a watercourse
- Green grasses that are suffering from moisture stress e.g. 4–6 weeks after rain
- High temperatures and low humidity
- Burn during the hottest part of the day
- Rubber vine that is growing strongly with the sap rising after the first storm
- Storm-burning will maximise damage to rubber vine, while minimising damage done to more sensitive target species.

Vegetation response

Once a dense cover of woody plants becomes established, it can be difficult to control. The effect of woody plants shading-out or otherwise out-competing grasses 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. Repeated dry season burning at Wambiana helped to maintain an open vegetation structure, but, when accompanied by drought, fire led to deterioration of pasture condition (O'Reagain and Bushell 2011). On Cape York Peninsula, a regime of storm-burning every two to three years opened up country and restored a grassy understorey (Crowley *et al*. 2009).

When to burn?

The preceding sections explain the benefits of storm-burns as opposed to mid- to late-dry season burns (Table 10). However, whenever a

Table 10. Characteristics of fires lit in different seasons (Smith 1960; Crowley and Trueman 2007).

Season of fire	Benefits	Disadvantages
Early-dry season	Help prevent the spread of late dry season wildfires by removing ground layer fuel. Burnt strips of ground can form a network of control lines along with other barriers, such as roads, tracks, and rivers. When lit late in the afternoon, are likely to go out overnight, so are easy to control.	Can cause vegetation thickening by removing grasses that compete with woody regrowth. Woody plants draw on soil moisture through the dry season, so will already be above the grasses that resprout with the first rains. Can also damage actively growing perennial grasses and cause their replacement by annual grasses.
Mid-dry season	May be useful to help extend fire breaks if there is already a network of early burn established.	May get out of control and burn for several weeks. Can contribute to vegetation thickening by removing grass cover.
Late-dry season	Can maintain and restore open vegetation structure. Can help to create nesting hollows in the tops of trees that are needed by hollow-nesting birds and mammals.	Extremely difficult to control and can burn extensive areas of pasture and eliminate native animals by destroying large areas of habitat. Exposes soil to erosion, may destroy canopy trees and can endanger human life and property.
Storm-burn	When used skilfully, help restore open vegetation communities without causing extensive damage to forage, habitats, or canopy. Most effective when lit 2-3 days after the first heavy storm, when the sap has risen in woody plants, but before most grass seed has germinated.	Timing can be difficult and impossible in years when the first rains are widespread and persistent. Can spread uncontrollably if lit when rain has been insufficient or patchy. If lit too long after the first rains, can cause loss of ground cover and soil erosion.
Wet season	Can be effective at removing unwanted groundcover species.	Highly likely to damage 3P grasses by destroying top-growth when underground reserves are low. Resultant loss of cover at time of high rainfall can lead to soil erosion.

fire is planned, the environmental, especially fuel and climatic, conditions should be taken into account. 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 long residence times may actually lead to higher mortality rates of some trees and shrubs.

How often to burn?

A regime of multiple fires is often necessary to achieve ongoing effective control of woody plants (Grice 1997b). Analysis of fires aimed to control rubber vine along riparian vegetation in the Burdekin showed that sally wattle and strap wattle increased in density after one fire, but declined after a series of fires (Radford *et al*. 2008). Rubber vine was the only species that showed an unambiguous decrease in numbers after repeated fires, regardless of season. Single fires resulted in increases of some woody species whereas two consecutive fires led to decreases, but had little overall floristic effect on plant communities. Overall, fire reduced density of some tree size-classes as well as rubber vine. Storm-burning aimed at controlling rubber vine caused less off-target damage than did dry season burning, although it took more than one fire to achieve the same level of rubber vine control.

Currant bush was found to continue to increase in unburnt plots, but not in plots burnt after the first wet season rains (Back 1998, 2005; Radford *et al*. 2008). However, two or more fires were required to sustain the reduction in currant bush (Figure 16).

How often is it possible to burn?

Bio-economic modelling during NGS was used to explore how often sufficient fuel is available for a mild or hot burn under five different stocking rates. Three land types were used to cover the range of productivity: black basalt; red goldfields; and yellowjacket. The property was assumed to be in good condition and stocked according to long-term carrying capacity. Without burning, tree basal area increased between 1980 and 2005 (Figure 17) and perennial grasses declined (Figure 18). The results showed that fires are required every four years to keep the country open, but that the ability to burn country this often is affected by land type, tree cover and stocking rate.

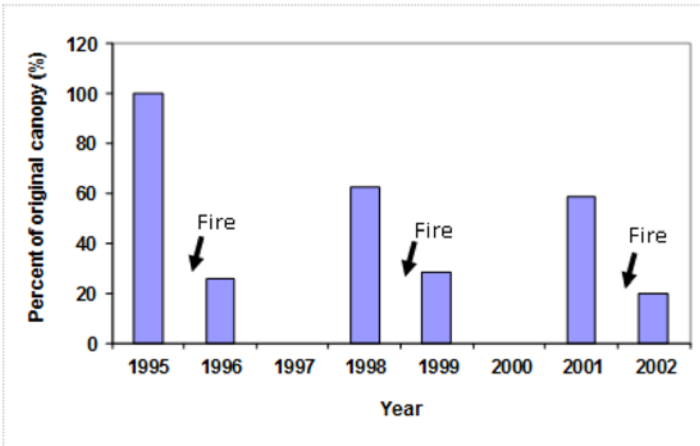


Figure 16. The response of currant bush to wet season fire (Back 2005).

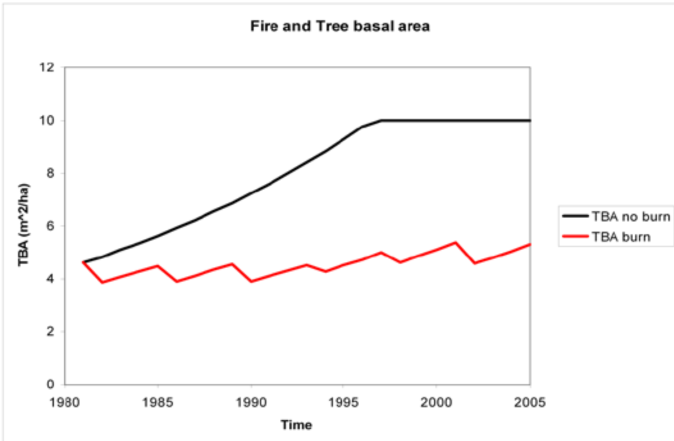


Figure 17. The effect of burning every fourth year on tree basal area (TBA).

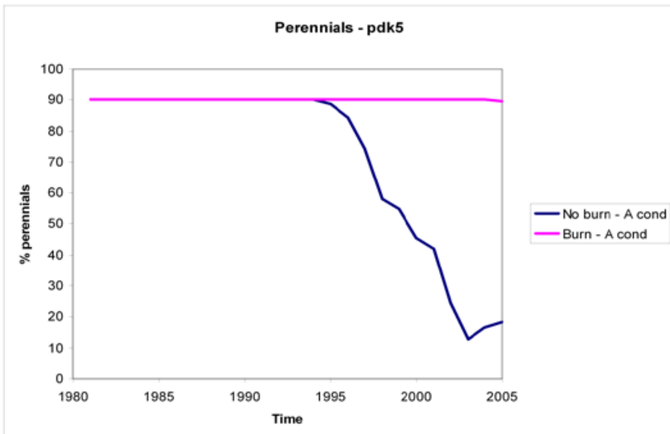


Figure 18. The effect of burning every fourth year on the proportion of perennial grasses in the pasture and hence land condition.

Without trees and under moderate stocking rates, there was sufficient fuel to carry mild fires in more than 70% of years and hot fires in 50% of years on basalt country. Once stocking rate increased to 2.5 ha/AE however, hot fires could be achieved in only 10% of years. In the less productive red goldfields and yellowjacket land types, fuel load declined substantially as stocking rate increased and lighter stocking rates were needed to promote fuel loads for up to 50% of years. Heavier stocking rates failed to achieve the 2000 kg/ha fuel load needed to carry hot fires (Figure 19).

Implementation

- Implementation of a regime of prescribed burning to manage woody plant populations requires planning. The emphasis should be on a fire regime rather than on individual fires e.g. best regime for species such as currant bush or rubber vine is to plan two consecutive storm-burns. The types of fire regimes will differ between currant bush, rubber vine, eucalypts, and wattles. The response of the target species should be part of the planning (e.g. Tables 8 and 9).
- Assess the need for fire. The use of fire should be targeted, with clearly defined objectives identifying the species of woody plants to be managed and the fire regime (type, frequency, intensity) to be applied.
- Paddocks should be prioritised for burning and coupled with grazing and spelling strategies to make best use of the years which are suitable for burning.
- Plan to construct, appropriate fire breaks well in advance of burning, if required.
- Ensure adequate and suitable equipment and labour are available and necessary permits are obtained

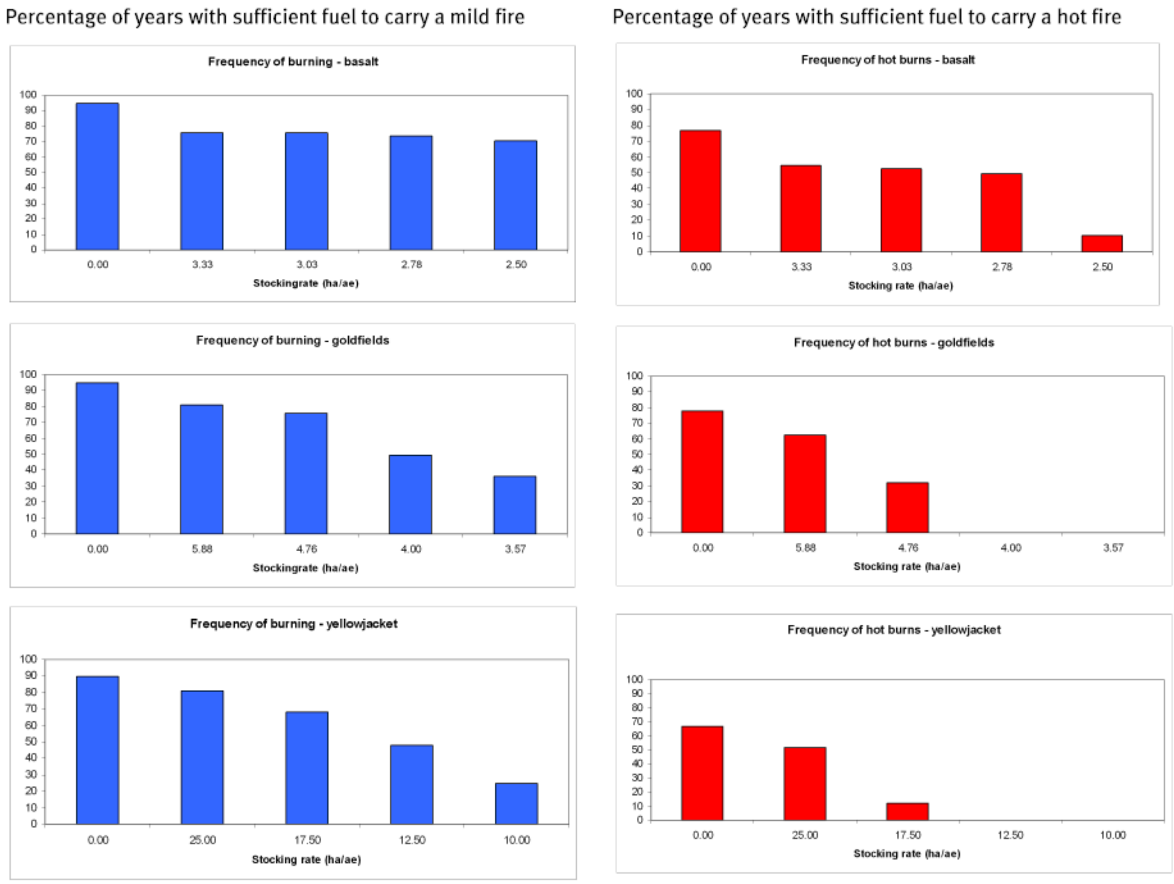


Figure 19. The proportion of years in which fuel was sufficient to carry a) a mild fire (800 kg/ha of fuel) and b) a hot fire (2 000 kg/ha of fuel) within black basalt, gold fields or yellowjacket land types under increasing stocking rates (from NGS).

- Choose the precise time of the fire by considering wind, temperature, humidity, fuel moisture levels, and fuel continuity. The aim is to produce a fire with a long residence time at the base of trees and shrubs. Therefore the most appropriate fire is often a 'back' burn depending on conditions.
- 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 — especially in less productive land types.
- Ensure accumulation of at least 2000 kg/ha of pasture yield as fuel, suitably distributed across the target area(s). Fires should be timed to take advantage of seasonal conditions that facilitate the accumulation of fuel and minimise effects on short-term carrying capacity. Pre-fire spelling of pastures intended for prescribed fires may be necessary depending on the seasonal conditions. Forage budgeting at the property scale will be helpful here. It may be necessary to spell during the growing (wet) season to ensure adequate fuel accumulates and during the subsequent dry season so that fuel persists until the time of the fire.
- Continue spelling into the post-fire period to ensure grazing does not damage pasture plants as they recover from the effects of burning. This will be especially important if the immediate post-fire wet season is a poor one.
- Re-burn the area within one to three years depending on the rate of fuel accumulation. A fire regime that involves burning twice in quick succession (either in consecutive years or in years one and three) is likely to be more effective against woody plants than a single fire.
- Reassess the need for further burning within five years after the second fire and in subsequent years. A regime of two fires every ten years may be necessary but do not burn unnecessarily. Take advantage of seasonal conditions in deciding when to burn.

Considerations and caveats

The use of prescribed burning in the Burdekin has declined in recent years. Possible reasons include:

- Economic pressures and the potential costs of burning to cash flow
- Dry seasons and lack of fuel — use the feed rather than burn it
- Uncertainty of follow-up rain
- Reducing knowledge and experience with fire as a land management tool in the grazing community and some poor responses to single occurrence fires or wildfires
- Legislation and fear of litigation
- Community perceptions of fire as being deleterious/undesirable.

The costs associated with burning can range from the foregone income of spelling pastures to build a fuel load, the deferred grazing following the burn as pastures recover and the costs of conducting the burn itself (e.g. costs of equipment and labour during the burn, the cost of extra firebreaks). As with any management practice, the costs and benefits need to be considered in planning the burning strategy. Most of the costs of burning are in the short term. The costs of not burning are in the long term as pasture productivity and carrying capacities decline and may need to be addressed through even more expensive measures such as mechanical or chemical control.

As part of the potential benefits from burning, consider the opportunities for establishing improved pastures e.g. legumes into the ash bed to increase carrying capacity above the potential for native pasture.

When planning a burning regime, bear in mind that burning when fuel loads are inadequate is unlikely to achieve the purpose of the fire and may be counterproductive.

Similarly, grazing in the immediate post-fire period generally hinders the recovery of desirable pasture species. Ideally, 3P grasses are allowed to set seed in the post-fire period and this may require destocking or, at least, very low stocking densities. If pre or post-fire destocking is necessary, forage must be available for livestock on other parts of the property or off-property or they would have to be sold.

Drought following fire is a risk that discourages many graziers from using prescribed burning. The overall management system should consider options to reduce this risk such as de-stocking strategies, using the SOI as a guide to burning (e.g. if the SOI is strongly negative, the option to defer burning may be taken to reduce the risk of feed shortages. Conversely, some managers may consider the extra death of woody plants during drought following a burn as an incentive to continue as planned).

Findings from the Ecograze project showed that plant mortalities after fire may be increased among drought-stressed woody plants. The practicality of achieving sufficient fuel loads in dry years is low and graziers are unlikely to burn in this situation.

Fire can promote germination of some woody species, e.g. wattles in the Desert Uplands. It is important to monitor the area in the post-fire period to be able to respond appropriately to large-scale germination events. If large recruitment events are triggered by a fire, a second fire will be necessary. Conducting a second prescribed fire before recruits set seed could reduce the build-up of soil seed-banks. (Many wattles do not set seed until they are three years old).

Consider the risk of soil loss associated with exposing areas for long periods when burning, particularly on erodible soils and slopes.

Also consider the risk of damaging pasture. Damage to perennial grasses is highest when they are actively growing (Smith 1960).

The risk of liability and breaching legislation are often cited as reasons not to burn. Certainly the risk of a controlled burn becoming a wildfire must be considered and planned for. Obtaining a permit to burn when there is a high likelihood of this occurring may be difficult. Burning without a permit is illegal and opens up the possibility of litigation from neighbouring landholders that are affected. Often the woody plant problem to be addressed requires the type of fire that may get out of control; this is a difficult conundrum for graziers and fire wardens. Graded fire breaks or late wet season burning to establish fire breaks and strategic grazing can be used to reduce loads to manage the risk of fires entering neighbouring properties and non-target areas.

The legislation for clearing trees is essentially the same if using fire, mechanical or chemical methods. The application process for clearing encroaching or thickening woody vegetation requires the historical changes in the density of woody plants to be documented e.g. by comparing the oldest with the most recent aerial photography (most of the Upper Burdekin catchment has early aerial photo coverage from the period 1943 to 1951) or through ground based photo-sites. There may be value in seeking professional assistance to prepare applications.

Options other than fire, such as mechanical or chemical control, may be considered when the woody plant density prevents the accumulation of adequate fuel loads. The practicality of these options needs to be assessed on a case by case basis and within the provisions of the *Vegetation Management Act 1999*.

Permits, as required by law, should always be sought and the conditions followed for prescribed burning.

Complementary management option: Match stocking rate to long-term carrying capacity

Heavy grazing over long periods may promote woody plant proliferation by reducing the competition that woody seedlings face from perennial grasses. It also reduces the opportunity for conducting prescribed fires. Good grazing management increases the window of opportunity for incorporating effective fire into the management system.

A fire regime requires the parallel implementation of a stocking strategy that allows for fuel build up before burning and pasture recovery afterwards. For management systems in which the incorporation of fire is the preferred option for managing woody plants, it is critical to integrate grazing and fire regimes.

Evidence

Fire and grazing compete for grass yield. Accepting 2000 kg/ha as a minimum fuel load for an effective fire for woody plant management, this threshold will be reached more frequently in higher rainfall zones or on the more productive land types and where stocking rates are lower (refer to Figure 19).

Implementation

- Undertake land condition monitoring and forage budgeting to calculate a stocking rate that will maintain a healthy pasture condition, following the recommendations in Chapter 6 for A/B condition land and Chapter 7 for C condition land.
- A minimum pasture yield for a fire that will be useful in controlling woody plants is around 2000 kg/ha. Ensure this amount of fuel is left by destocking at the appropriate time in the season before fires.
- Do not allow livestock to graze burnt areas until the 3P grasses have recovered substantial biomass. This is particularly important where small areas are burnt, as cattle will congregate.

Considerations and caveats

Matching stocking rate to long-term carrying capacity increases the prospects for incorporating fire into a management system. It is important to burn when conditions are suitable which may mean waiting for the appropriate season, probably reducing the costs of burning in terms of lost animal production.

Feral animals e.g. pigs and deer that use thickets of woody weeds for shelter should be controlled as these animals spread seed e.g. chinee apple, mesquite.

Complementary management option: Implement wet season 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 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 3P grass tussocks to recover from having been burnt and, ideally, to set seed. Wet season spelling of pastures after fire also maximises competition against woody plants.

Annual wet season spelling and no dry season grazing may maximise the frequency of burning opportunities – particularly for hot fires. Treating paddocks in this way means little or no productivity in the short-term. However, as land condition improves, the required frequency of burning and wet season spelling will decline and the carrying capacity of the land will increase.

Evidence

Grazing studies conducted in both the Burdekin catchment and the Victoria River District (VRD) of the Northern Territory provide evidence for the effect of pre and post-fire spelling on pasture yield (Dyer *et al*. 2003; Ash *et al*. 2011).

Implementation

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

Considerations and caveats

Where paddocks contain dense areas of woody plants, it may be necessary to trap cattle to achieve clean musters and to ensure an effective wet season spell. The presence of surface water will determine the practicality of this option.

Complementary management option: Integrated weed management

Control of exotic weeds is important for maintaining pasture condition and production and may also be the legal responsibility of the grazier. Information on identification and management required for eradication, containment and control exists for significant weeds, such as Queensland declared plants and Weeds of National Significance (refer to ‹www.weeds.gov.au› for advice on nationally listed species and ‹www.daff.qld.gov.au/› for advice on Queensland declared plants and other weeds recognised as problem plants in Queensland).

Integrated weed management uses the best combination of approaches to weed management, rather than depending on chemicals as a first option. There are six principles to integrated weed management:

1. Awareness
2. Detection
3. Planning
4. Prevention
5. Early intervention
6. Control and monitor

Evidence

Integrated weed management saves on the use of chemicals and minimises risks to livestock and the environment (refer to the Queensland and Australian Government websites for further details).

Implementation

- **Awareness**
  Get to know the plants on your property, so that you will immediately recognise something that should not be there.
  Familiarise yourself with significant weeds, both ones that are in the area and ones that are on Alert lists.
  Know the best weed management options, particularly those that fit in with other management approaches, such as fire or grazing regimes.
- **Detection**
  Watch out for new weeds, particularly around waterways, troughs, feedlots, in hay, along entry tracks, and anywhere machinery that has come from another property has been working (such as where cables are laid).
- **Planning**
  Mark where the weeds are on a property map. Identify outlying weed stands that can be eliminated and work on these first. Allocate time and resources to weed control. Keep a record of where you have treated weeds. Plan follow-up treatment before the weeds has recovered to its former proportions. If necessary, coordinate your weed control efforts with neighbours or catchment groups.
- **Prevention**
  Use good weed hygiene. Do not buy infested hay, or plant garden plants with a high weedy potential. Wash down machinery that has been in weed infected areas before moving to clean areas and ensure contractors working on your property do the same. When handling cattle, look out for seeds and burrs of problem plants.
- **Early intervention**
  When you detect a strange plant, get it identified. If it is a problem weed, control it as soon as possible. Look around to see if there are any other outbreaks. Carry a spray pack with you if you think you are likely to come across isolated weeds, especially in remoter parts of the property.
- **Control and monitor**
  Find out the best treatment for each weed, whether it is physical, fire, grazing, browsing, or chemical (refer to Chapter 14), or a combination. Do the hard physical work, whether this is chipping out roots or injecting stems with poison. Approach control strategically, eradicating isolated plants, attacking larger stands from the outside in and working from the top-end of the catchment to the bottom. Return to see how effective the treatment has been and use the most effective methods on other stands.

Considerations and caveats

Graziers have little control over natural forces that spread seed, such as floods and wind, or even bird movement. However, they can prevent weed spread on machinery and, to some extent, livestock.

Control methods should be based on the best published advice and include only those chemicals that are registered for use against a particular weed (refer to Chapter 14 for more information).

Consideration should also be given to using other animals such as camels and goats within an integrated woody plant management program. They are not a replacement for a good woodland management program but may provide a useful tool within the overall program.

Be mindful of environmental values when controlling weeds. Fire in riparian areas is effective at controlling rubber vine, but if not managed well can destroy plants that are an important part of the ecosystem, providing riverbank stabilisation or nesting hollows. Chemicals used near waterways have the potential to cause fish-kill or loss of water plants and algae (refer to Chapter 14 for more information).

Interactions - animal production, profitability, land condition and water quality outcomes

In the short term, animal production is likely to be reduced as paddocks are spelled and/ or burnt, reducing financial returns. However, in the long term, both grazing capacity and land condition will be maintained or improved leading to increased animal production and greater returns. With reduced competition from woody plants and managed grazing, ground cover levels will be high with positive impacts on water quality.

Toolbox

Australian Weeds Committee, *Weeds Australia National Portal*, ‹www.weeds.org.au›.

Burdekin Shire Council 2012, ‹www.burdekin.qld.gov.au/›.

Charters Towers Regional Council, ‹www.charterstowers.qld.gov.au/web/guest›.

Isaac Regional Council, ‹www.isaac.qld.gov.au/›.

Mackay Regional Council, ‹www.mackay.qld.gov.au/›.

Meat and Livestock Australia, Department of Agriculture, Fisheries and Forestry & Northern Territory Department of Resources, 'Managing Weeds' module, EDGE*network Grazing Land Management workshop*, Meat and Livestock Australia & State of Queensland (Department of Agriculture, Fisheries and Forestry).

Nelson, B, Smith, D, McCullough, M, Robinson, E, McKellar, K, Holmes, B, Best, M & Gowen, R 2008, *Research to reality: Practical solutions to beef enterprise issues in the Burdekin Catchment*, State of Queensland (Department of Primary Industries and Fisheries), Burdekin Dry Tropics & CRC Beef.

Townsville City Council, ‹www.townsville.qld.gov.au/Pages/default.aspx›.

Whitsunday Regional Council, ‹www.whitsunday.qld.gov.au/web/guest›.

For current DAFF workshops please refer to the Future Beef website ‹www.futurebeef.com.au›.

Carbon Farming

Department of Climate Change and Energy Efficiency, *Carbon Farming Initiative, Savanna fire management methodology*, Department of Climate Change and Energy Efficiency, ‹www.climatechange.gov.au›.

Department of Climate Change and Energy Efficiency, *Carbon Farming Initiative, savanna burning*, Department of Climate Change and Energy Efficiency, ‹www.climatechange.gov.au›.

Chapter 14. Managing chemicals – herbicides and fertilisers

Chemicals and fertilisers used in agriculture can cause problems if they are lost from the property and particularly if they enter the stream network. The use of chemicals, in particular herbicides and fertilisers, on grazing lands in the Burdekin catchment is much lower than in more intensive agricultural areas. However their use still needs to be well managed to prevent any undesirable side effects.

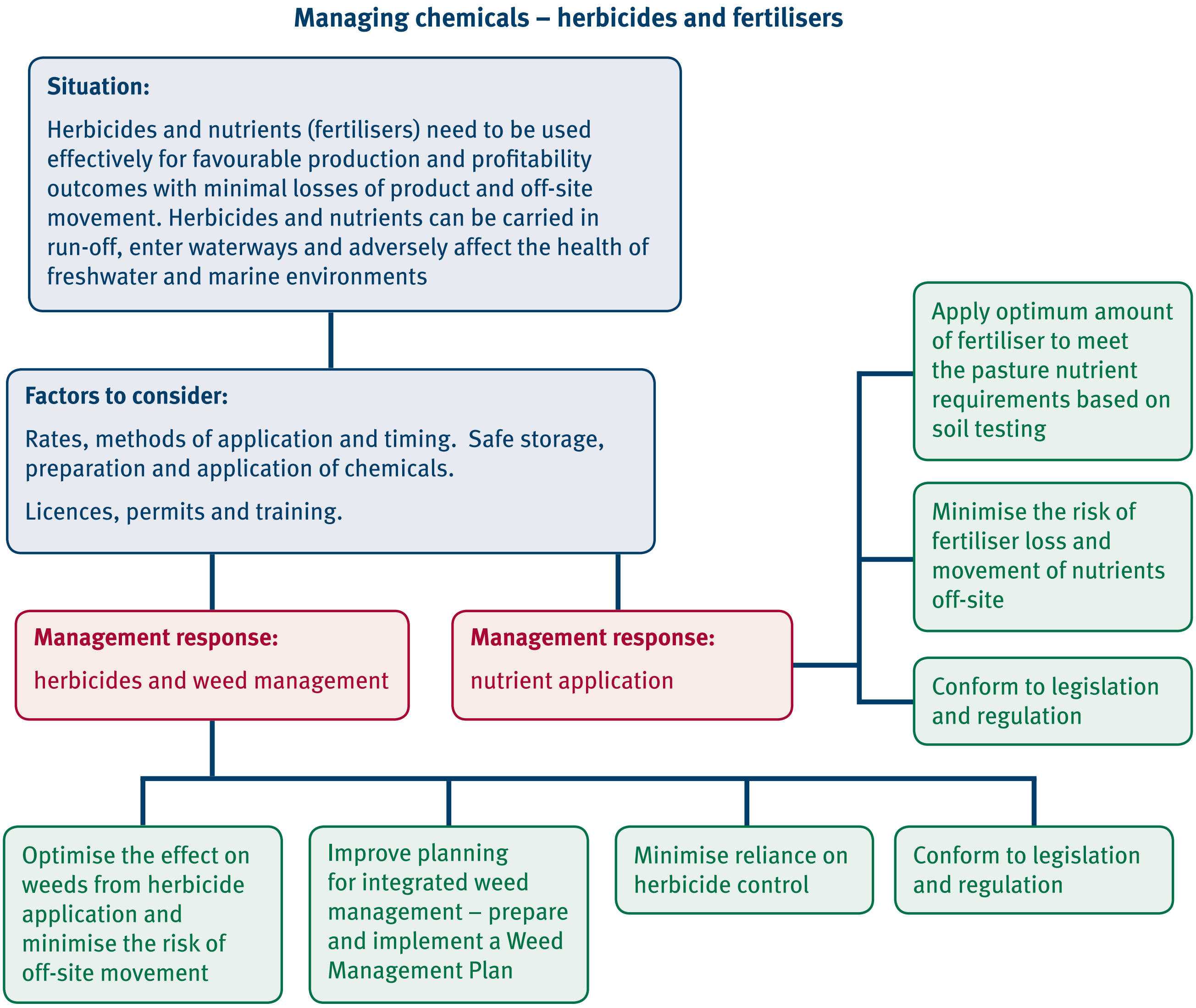


Figure 20. Diagram showing how this chapter on managing herbicides and fertilisers is structured

Situation

The application of broad-scale chemicals (herbicides and fertilisers) on extensive grazing lands is much lower than in more intensive agricultural cropping areas in the Burdekin catchment.

Herbicides are most widely used. Of these, tebuthiuron is applied once in several years for the control of woody vegetation. Tebuthiuron is applied by hand or aerially; application under certain conditions, such as before heavy rainfall, can lead to off-site movement to non-target areas like waterways. Application of other herbicides is generally by ground boom or boom-less jets, aerial, or foliar spraying that use high volumes of chemicals over large areas and have a high risk of off-site movement through drift, run-off, and soil movement.

Fertilisers are not often used on extensive grazing lands other than for the re-establishment of pasture, establishment of crops, and for special pastures such as leucaena.

Urea and phosphorus supplements represent a very small proportion of the total nitrogen and phosphorus in grazing systems. However, cattle congregate at supplement points reducing ground cover making them prone to erosion. Soils at a supplement point are likely to have higher nutrient levels from dung, urine and possible supplement spills. Supplement points should not be located adjacent to streams to reduce chances of this soil being eroded into the stream. This will not be discussed further in this chapter.

Overall the use of herbicides and fertilisers still needs to be well managed to:

- be effective for production and profitability
- minimise losses of product and off-site movement of herbicides and nutrients (from fertilisers). Herbicides (attached to soil particles and in solution) and nutrients can be carried in run-off, enter waterways and adversely affect the health of freshwater and marine environments.

Factors to consider

Rates, methods of application, timing

For herbicides and fertilisers to be used effectively with minimal loss of product, application rates, methods of preparation, and application as well as timing need to be carefully considered. Monitoring and recording the effects of herbicide applications (and alternatives to herbicide use) are important aspects of integrated Weed Management Plans. Refer to Table 11.

Safe storage, preparation and application of chemicals

Refer to the instructions on the label for the safe storage, preparation and application of chemicals. Be aware of the relevant legislation and regulation, such as the *Chemical Usage (Agricultural and Veterinary) Control Act 1988*.

Licences, permits and training

To apply certain chemicals such as tebuthiuron, accredited training is required. Before applying herbicides or fertilisers, check for any licences, permits or training that may apply.

For more information, refer to the Department of Agriculture, Fisheries and Forestry and ReefWise farming – Department of Environment and Heritage Protection, websites.

Herbicides and the Great Barrier Reef

Certain types of residual herbicide regularly used in agricultural systems have been detected in waters of the Great Barrier Reef (GBR) and are considered to pose a threat to reef water quality. Those herbicides include tebuthiuron, diuron, atrazine, ametryn and hexazinone.
In Queensland, tebuthiuron is sold as many products including Graslan®, Graslan Aerial®, Tebulan 200GR®, Scrubmaster 200®, Titan Tebuthiuron Aerial® or Titan Tebuthiuron®.

Management responses: herbicide and weed management

The overall aim is to optimise the effect on weeds from herbicide application and reduce the emergence and spread of weeds through various methods of control and planning. Table 11 lists the management responses and provides the options and what needs to be considered when choosing these options.

Evidence, implementation, considerations and caveats

Seek advice on land clearing and vegetation management laws from your local council and Department of Natural Resources and Mines before herbicide application. For example, tebuthiuron e.g. Graslan cannot be used in remnant vegetation.

Note for aerial distribution of tebuthiuron, do not apply:

- between 1 November and 31 March each year (inclusive). The biggest risk of tebuthiuron being lost to streams is if heavy storms occur soon after application. Therefore it should only be used during the dry season when no rain is forecast.
- more than 4.6 kg of active ingredient per hectare in any three year period
- any more than two applications totalling 6.8 kg of active ingredient per hectare in any six year period
- if it is raining over the application area
- if wind speed is greater than 20 km per hour
- within 20 m of drainage lines greater than 20 m wide
- on steep slopes or within 100 m of streams.

Also, prior to aerial application, you must:

- identify all drainage lines greater than 20 m wide in the area of application.
- produce an image map of the application area indicating the boundary of the area, water bodies and drainage lines, with five or more visible points on the image that correspond to identifiable fixed features.
- have in position an on-ground observer to assist in the identification of areas not to be treated during application.

Table 11. Management responses, options and considerations for effective use of herbicides (adapted from Department of Environment and Resource Management (2010).

Management responses	Management options (What can I do?)	Considerations
Optimise the effect on weeds from herbicide application and minimise the risk of off- site movement	**Control strategies** Consider the weed type and density when choosing appropriate control strategies.	The most efficient herbicide application methods must be used to prevent herbicide being applied near or in water bodies. The optimum timing of spray needs to be determined to best reduce seed bank and weed pressure over time (e.g. before dispersal of seeds).
	Herbicide and rates Consider most appropriate herbicide product mix and application rates for control of weeds.	Identify if residual herbicides could be replaced effectively with knockdown herbicides, taking account of potential resistance issues. Follow label instructions and identify the amount required to effectively to treat weeds.
	Equipment Ensure equipment is suitable and appropriate for each application of herbicide.	The sprayer must have correct nozzle selection and design. Pressure and vehicle speed should be appropriate to the job and equipment calibrated before each job.
	Method Using ground booms, boomless jets, aerial and foliar spraying.	Application methods using ground booms, boomless jets, aerial and foliar spraying can deliver high volumes of chemicals over large areas increasing the risk of herbicides being carried in run-off and moving off-site.
	Timing Consider weather conditions and do not apply in conditions that are likely to cause drift or off-site movement in run-off.	Do not apply if rain is forecast up to 48 hours after application. Delay application until after annual flooding. Do not apply in strong winds (>20 km/hr).
	Preparation, application and disposal Do not prepare, use or dispose of herbicides in places where herbicides could easily enter a water body.	Consider areas where herbicides could easily be transported into water bodies (e.g. areas of soil moisture, slope, compaction or close proximity to water bodies). Always refer to label for instructions when applying herbicides near water bodies. Contact your local/ regional council for information on the control of weeds within water bodies or riparian zones.
Improve planning for integrated weed management (prepare and implement a Weed Management Plan)	**Weed Management Plan** Implement a Weed Management Plan to reduce the emergence and spread of weeds over time.	Refer to the section in Chapter 13 on integrated weed management that saves on the use of chemicals and minimises risks to livestock and the environment. It includes: • being aware of plants on the property • detecting new weeds • planning – mapping weeds, allocating time and resources to weed control, recording treated weeds, planning follow-up treatment and co-ordinating with those in area if necessary • prevention by using good weed hygiene to prevent the spread of weeds • early intervention and identifying the best control treatment and monitoring • control and monitoring – taking note of weed pressure over time to identify potential sources of spread; monitoring and recording the effects of herbicide applications and alternatives to herbicide use.
Minimise reliance on herbicide control	**Other weed control methods** Use of mechanical or other controls as replacement or in combination with herbicide controls as part of an integrated Weed Management Plan.	Chemical controls can be used in combination with other management options that promote grass growth including manual control (hand grubbing and hand cutting), mechanical control, slashing/mulching, stick raking/pushing, mechanical grubbing, chain pulling, ploughing, biological control (e.g. insects), and fire (where applicable to weed type and with appropriate permits and planning). Mechanical control may cause disturbance to the soil and desirable vegetation, potentially causing soil erosion. Identify time of year with low chance of heavy rain.
Conform to relevant legislation and regulation	**Relevant legislation and regulation** Check relevant legislation and regulation for the application of chemicals .	Examples include: • label conditions • Chemical Usage (Agricultural and Veterinary) Regulation 1999 for tebuthiuron – ground and aerial distribution requirements including not preparing or applying at a place where it can easily run-off (e.g. into a water body or drainage line); timing with respect to weather conditions and time of year and application rate • requirements for record-keeping in Chapter 4A of *Environment Protection Act 1994* – Great Barrier Reef Protection measures • *Vegetation Management Act 1999*.

Management responses: nutrient application

The aim is to apply the optimum amount of fertiliser to establish pastures and minimise the risk of product losses and off-site movement of nutrients into waterways (refer to Table 12).

Interactions - animal production, profitability, land condition and water quality outcomes

It is unlikely there will be widespread use of fertilisers in the grazing lands in the near future as the animal production responses to their use are generally uneconomic. Under these circumstances they do not pose a threat to water quality. If they were poorly used they could pose a threat to water quality.

Table 12. Management responses, options and considerations for effective use of fertilisers (adapted from information presented in Department of Environment and Resource Management (2009 and 2010).

Management responses	Management options (What can I do?)	Considerations
Obtain a recommendation on the optimum amount of fertiliser to meet the pasture nutrient requirements based on soil testing	Prepare a nutrient management plan based on soil test results.	Nutrient management plan records applications of all nutrient sources and pasture yields. Soil testing provides a guide to the nutrient concentration in the soil and helps to fine tune management by applying rates that better meet the needs of the plant. This approach reduces the risk of over-fertilising, incurring unnecessary costs and excess nutrients impacting on water quality.
	Split applications of fertiliser	Nutrients are applied at a time: – when pasture will best use the nutrients and losses of nutrients, environmental and animal health problems minimised.
Minimise the risk of fertiliser loss and movement of nutrients off-site	Application timing	Fertiliser for pastures applied after the first storms, but before the main wet season to aid plant uptake. Fertiliser incorporated into the soil at planting on a prepared seedbed. In both cases, fertiliser should not be applied when heavy rain is forecast (e.g. major storm events) due to heavy rainfall increasing the risk of loss occurring through run-off.
	Applications take into account proximity to waterways	Do not apply nitrogen fertiliser directly adjacent to waterways. When nutrients are applied adjacent to waterways there is a higher risk of excess nutrient run-off entering waterways. Nutrients such as nitrogen can be carried in water easily, especially when applied during periods of high rainfall. Phosphorus will also move off site if erosion is occurring because it bonds to soil particles.
Conform to relevant legislation and regulation	Check relevant legislation and regulation for the application of fertilisers	For example: Chapter 4A of *Environment Protection Act 1994* – Great Barrier Reef Protection measures. For more information, refer to Department of Environment and Resource Management (2009) *A guide for applying nitrogen and phosphorus on grazing properties regulated under the Environmental Protection Act 1994*.

Toolbox

Australian Weeds Committee, *Weeds of National Significance*, ‹www.weeds.org.au/WoNS/›.

Burdekin Shire Council 2012, ‹www.burdekin.qld.gov.au/›.

Charters Towers Regional Council, ‹www.charterstowers.qld.gov.au/web/guest›.

Department of Agriculture, Fisheries and Forestry, *Weeds, pest animals and ants*, State of Queensland (Department of Agriculture, Fisheries and Forestry), ‹www.daff.qld.gov.au›.

Department of Environment and Resource Management 2010 'Part G – Herbicide Management plan' & 'Part H – Fertiliser Management plan', *Guide: Cattle Grazing Environmental Risk Management Plan (ERMP)*, State of Queensland (Department of Environment and Resource Management).

Department of Environment and Heritage Protection, *ReefWise Farming*, State of Queensland (Department of Environment and Heritage Protection), ‹www.reefwisefarming.qld.gov.au/›.

For further information on managing chemicals - herbicides and fertilisers:

- 'Climate Change and pollution – why the Great Barrier Reef is in trouble'
- '*Great Barrier Reef Protection Amendment Act 2009*'
- 'Keeping records of chemicals applied on your property'
- 'Principles to guide the preparation of weed management plans'
- 'Record Keeping fact sheet'
- 'Reef Protection Herbicide List – Cattle Grazing Environmental Risk Management Plan (ERMP)'
- 'Soil Testing fact sheet'
- 'Training for the use of certain agricultural chemicals'
- 'Use of tebuthiuron on cattle grazing properties'

Isaac Regional Council, ‹www.isaac.qld.gov.au/›.

Mackay Regional Council, ‹www.mackay.qld.gov.au/›.

Rolfe, J, Golding, T & Cowan, D 1997, *Is your pasture past it? – The glove box guide to native pasture identification in north Queensland*, State of Queensland (Department of Primary Industries).

Townsville City Council, ‹www.townsville.qld.gov.au›.

Whitsunday Regional Council, ‹www.whitsunday.qld.gov.au›.

For current DAFF workshops please refer to the Future Beef website ‹www.futurebeef.com.au›.

General toolbox

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Ash, A, Corfield, J & Ksikisi, T, T*he Ecograze Project: developing guidelines to better manage grazing country*, CSIRO Sustainable Ecosystems, Townsville, Australia.

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Department of Environment and Heritage Protection, *ReefWise Farming*, State of Queensland (Department of Environment and Heritage Protection), ‹www.reefwisefarming.qld.gov.au/›.

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EverGraze, *The EverGraze feed budget and rotational planner*, EverGraze & Meat and Live Stock Australia.

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Meat and Live Stock Australia, *Demonstration of rotational grazing to increase production*, ‹www.mla.com.au›.

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Milson, J 2000, *Trees and shrubs of north-west Queensland*, State of Queensland (Department of Primary Industries).

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The following organisations provide training courses to assist in the sustainable management of the Burdekin grazing lands. Please refer to the organisations website to view current courses offered.

- Australian Agriculture College Corporation (AACC)
- Resource Consulting Services (RCS)
- AgForce
- Meat and Livestock Australia (MLA)
- Grazing BestPrac.

For current DAFF workshops please refer to the Future Beef website ‹www.futurebeef.com.au›.

Botanical and common plant names

Pasture plants

Botanical name	Common name
Aristida spp.	Wire grasses
Aristida calycina	dark wiregrass
Aristida ramosa	purple wiregrass
Astrebla spp.	Mitchell grasses
Astrebla elymoides	Hoop Mitchell grass
Astrebla lappacea	Curly Mitchell grass
Astrebla pectinata	Barley Mitchell grass
Astrebla squarrosa	Bull Mitchell grass
Bothriochloa spp	Blue grasses
Bothriochloa bladhii	Forest bluegrass
Bothriochloa ewartiana	Desert bluegrass
Bothriochloa pertusa	Indian couch grass
Calyptochloa gracillima	Tableland couch
Chloris divaricata	Slender Chloris
Chrysopogon fallax	Golden beard grass
Cynodon dactylon	Green couch
Cyperus spp.	Sedges
Dactyloctenium spp.	Button grasses
Dichanthum spp.	Blue grasses
Dichanthium fecundum	Curly blue grass
Dichanthium queenslandicum	King blue grass
Dichanthium sericeum	Queensland blue grass
Digitaria ammophila	Silky umbrella grass
Digitaria brownii	Cotton panic
Digitaria ciliaris	Summer grass
Eriochloa crebra	Tall cup grass
Fimbrystylis spp.	Sedge
Heteropogon contortus	Black spear grass
Heteropogon triticeus	Giant spear grass
Imperata cylindrica	Blady grass
Parthenium hysterophorus	Parthenium
Panicum decompositum	Native panic
Panicum effusum	Hairy panic
Paspalidium caespitosum	Brigalow grass
Pennisetum ciliaris	Buffel grass
Sporobolus pyramidalis	Giant rat's tail grass
Sporobolus virginicus	Marine couch
Stachytarpheta spp.	Snakeweed
Themeda triandra	Kangaroo grass
Themeda quadrivalvis	Grader grass
Triodia spp.	Spinifex
Triodia mitchellii	Buck Spinifex
Triodia pungens	Soft Spinifex
Tripogon loliiformis	Five-minute grass

Trees and shrubs

Botanical name	Common name
Acacia spp.	Wattles
Acacia aneura	Mulga
Acacia argyrdendron	Blackwood
Acacia cambagei	Gidgee
Acacia catenulata	Bendee
Acacia harpophylla	Brigalow
Acacia holosericea	Strap wattle
Acacia rhodoxylon	Rosewood
Acacia salicina	Sally wattle
Acacia shirleyi	Lancewood
Carissa ovata	Currant bush
Corymbia peltata	Yellowjacket
Cryptostegia grandiflora	Rubber vine
Eremophila mitchellii	False sandalwood
Eucalyptus coolabah	Coolibah
Eucalyptus crebra	Narrow leafed ironbark
Eucalyptus melanophloia	Silver leafed ironbark
Eucalyptus persistens	Box
Eucalyptus populnea	Poplar box
Eucalyptus shirleyi	Silver leafed ironbark
Eucalyptus similis	Yellowjacket
Eucalyptus thozetiana	Napunyah
Jatropha gossypiifolia	Bellyache bush
Parkinsonia aculeata	Parkinsonia
Prosopis spp.	Mesquite
Ziziphus mauritania	Chinee apple

Glossary of terms

Adult equivalent (AE) represents the intake of a certain type of animal. In Queensland 1AE equates to a 450kg steer and other animals are expressed as a proportion. (GLM Technical manual). It serves as a method of comparison between different types of animals (e.g. cattle versus sheep), breed of animal and class of animals (e.g. breeding cows versus steers).

Agistment is running stock on another person's land for a set fee per head.

Annual plants complete their life cycle from germination to death in one year.

Basal area (crown cover of perennial tussock grasses) is the area of the soil surface where living plants are attached.

Bioeconomic modelling is an integration of bio-physical and economic valuation within a framework of benefit cost analysis.

Crocodile seeder is a specialised planter used for sowing into a rough, unprepared seedbed consisting of a steel drum with 'shovels' welded to the round surface.

Cryptogam is a group of plants including algae, lichens, mosses, liverworts and fungi which form crusts when associated with surface soils.

Defoliation is the removal of plant material (leaves, stem etc.) by animals during the grazing process.

Dry cattle refer to steers and spayed females.

Dry matter yield /pasture yield/pasture biomass/standing dry matter is the quantity of pasture available for grazing, usually expressed in kilograms or tonnes per hectare of dry matter (kg/DM/ha) (dry matter is the non-water component of the feed).

Ecograze is a project initiated by Meat and Livestock Australia to improve understanding of the effects of grazing, spelling, fire and climate on the condition and productivity of open eucalypt woodlands in north eastern Queensland. ‹www.cse.csiro.au/publications/2002/EcograzeManual.pdf›.

EDGEnetwork is a program that offers practical learning opportunities to help producers gain knowledge and develop skills necessary to improve their livestock enterprises ‹www.mla.com.au/Research-and-development/Extension-and-training/EDGEnetwork›.

Ephemeral refers to streams and rivers that only discharge water during and immediately after rainfall and are generally dry (apart from isolated waterholes) when not flowing.

Forage budgeting is a tool that managers can use to refine stock numbers based on seasonal forage availability (short-term carrying capacity).

Frontage country is mostly flat and adjacent to a major watercourse (or wetland) and extends to the start of the upland area.

GRASP is a model of the climate-soil-plant-animal-management of perennial grasses of Northern Australia ‹www.longpaddock.qld.gov.au/grasp/index.html›.

Ground cover i.e. organic ground cover (%) is the proportion of the ground covered by pasture plants, plant litter, tree leaf litter, twigs, woody debris and organic crusts that cover the soil surface.

Herd models is a quantitative method of examining the interactions between cattle and paddocks ‹www.futurebeef.com.au›.

Holding paddock is a paddock used to temporarily hold stock.

Infiltration rate is the quantity of water entering the soil in a specified time interval ‹www.groundwater.org/gi/gwglossary.html›.

Land condition is the capacity of land to respond to rain and produce useful forage; it is a measure of how well the grazing land ecosystem is functioning.

Land type is an area of grazing land that has characteristic patterns of soil, vegetation and landform. A number of land types may be present on a single grazing enterprise.

Long-term Carrying Capacity is the average number of animals a paddock can be expected to support over a five-ten year period.

Perennial plants live for more than a year (perennial grasses regenerate from tussocks (producing tillers) as well as seed.

Photo-monitoring is recording changes in land condition over time by regularly photographing specific areas within a property and comparing them from period to period.

Pitting is a process to produce small depressions in the soil surface which act like small dams and trap water improving infiltration (e.g. by the use of a crocodile seeder).

Preferred grasses (3P grasses) are grass species which are perennial, palatable and productive to stock.

Rank refers to old, hayed off pasture that is low in nutritional value.

Residual yield is the standing pasture (green and dead) that you aim to have at the end of the season.

Riparian refers to any land that adjoins, directly influences, or is influenced by a body of water. Riparian zones are normally vegetated areas associated with streams and watercourses as well as wetlands.

Ripping refers to using a machine with a blade to cut through soil to reduce soil compaction, encourage water infiltration and improve growth of pastures/vegetation.

Rotational grazing is the practice of systematically rotating paddocks for grazing, to either spell paddocks, even out or maximize the use of available feed across a property.

Senescent refers to pasture that has aged and is decreasing in nutritional value.

Short-term carrying capacity is the number of animals that a paddock can support for a week, a month, a season or a year.

Sodic soils are soils where sodium makes up a high proportion (generally >6%) of the cations held on the surfaces of clay particles.

Soil fertility is related to its capacity to maintain consistent output with minimal input ‹www.soilhealth.com/soils-are-alive/what-is-in-soil/p-01.htm›.

Southern Oscillation Index (SOI) is calculated from the fluctuations in the air pressure difference between Tahiti and Darwin.

Spelling is resting paddocks from grazing, for all or part of a season.

- **Wet season spelling** is destocking pastures for the whole or part of the wet season to allow pastures plants to replenish reserves, set seed and allow seedling recruitment.

Stocking rate is the number of animals on a unit area for a specific period of time measured in number of animals per hectare or hectares per animal

Supplementary feeding provides animals with nutrients in amounts and combinations that the pasture is not providing at the time

Tree basal area (TBA) is the cross-sectional area (over the bark) at breast height (1.3 metres above the ground) measured in m^2/ha.

Utilisation rate is the estimated animal intake of pasture dry matter expressed as a proportion of pasture growth per season or nominated period.

- **Safe pasture utilisation rate (%)** is the proportion of annual forage growth that can be consumed by domestic livestock without adversely affecting land condition in the long term.

Vegetation Management Act was enacted in 1999 in Queensland for the regulation of clearing native vegetation on all tenures.

VegMachine is software for land managers to monitor changes in their land's ground cover and health ‹www.daff.qld.gov.au›.

Whoa-boy is trafficable diversion bank – an earth mound across a road or track to slow down and redirect the flow of water.

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