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Sustaining productive pastures in the tropics 2. Managing native grasslands

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Abstract

The grasslands of tropical Australia include the naturally treeless, grass dominated communities and the grassy understories of the widespread woodlands and shrublands. Information from the monsoon tallgrass, tropical and subtropical tallgrass, tussock grasslands (Mitchell grass) and *Acacia* (mulga) shrublands is used to show how management can influence grassland performance. Emphasis is placed on vegetation responses but effects on soil characteristics and animal production are also considered. The major management options considered are control of stock (numbers, species, breeds, when and where they graze), fire, feed supplements and timber treatment. Changes in land condition in the Burdekin catchment in response to management and seasonal conditions are outlined. The various options must be integrated and the role of decision support packages is considered.

Major changes are occurring in the northern grasslands and future management research should include studies of the ecology of the main grass species, the biology and management of woody plants, other pasture types (e.g. *Bothriochloa/Aristida* lands), stocking rate/animal production relationships, the costs and benefits of management practices e.g. temporary overgrazing, and grazing systems for changing pasture composition and animal production.

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Resumen

Los pastizales de Australia incluyen las áreas naturales sin árboles, las comunidades con predominio de gramíneas y la vegetación baja pastoreable de las áreas forestales y arbustivas. A fin de evaluar como el manejo puede influenciar el comportamiento de los pastizales se utilizó la información de las pastizales de tallgrass de monzón, tallgrass y tussock (Mitchell grass) del trópico y del sub-trópico y la vegetación arbustiva de Acacia *(mulga). A pesar de que el énfasis es puesto en las respuestas de la vegetación, se consideran también los efectos sobre las características del suelo y la producción animal. Las principales opciones de manejo estudiadas son: el control del ganado (cantidad, especie, raza, cuando y cuanto pastorear), el fuego, los suplementos alimenticios y el tratamiento de los árboles madereros. Se hace hincapié en los cambios de la condición de la tierra en la zona de captación de Burdekin como respuesta al manejo y a las condiciones estacionales. Las diversas opciones deben ser integradas y el papel de los paquetes de computación para el apoyo en la toma de decisiones es considerado.*

Los mayores cambios están ocurriendo en las pastizales de la región norte y las investigaciones futuras debieran incluir estudios de la ecología de las principales especies de gramíneas, la biologa y el manejo de las plantas leñosas, de otros tipos de pasturas (v.g. campos de Bothriochloa-Aristida*) las relaciones carga animal/producción animal, el costo y beneficio de la prácticas de manejo v.g. sobre-pastoreo temporal, y sistemas de pastoreo para modificar la composición de la pastura y la producción animal.*

Introduction

The grasslands of tropical Australia include the naturally treeless, grass dominated communities and the grassy understories of the widespread woodlands and shrublands. They have been used for extensive grazing by cattle and sheep for up to 150 years and will continue to be an important resource in the future. In these grasslands, herbage quantity and/or quality is the major limitation to animal production. Their relative importance varies — in wetter areas, herbage production is large and low quality during the dry season is the major constraint; in the drier areas where production is lower and less reliable and quality generally higher, quantity is more often limiting (Tothill *et al.* 1985). Although the large properties, low and variable returns, large capital requirements and maintenance costs limit the options that are economically viable, a number of strategies have been developed to increase animal production by overcoming or minimising the effects of low pasture quantity and quality.

Some deleterious changes have been associated with past use of these grasslands and in the future, management will need to consider effects on the condition of the vegetation and soils as well as effects on animal production. The aim must be sustainable animal production without degradation of the soil and vegetation resources. In this paper we examine the effects of various management options on animal production, vegetation characteristics and soil properties together with the role of decision support packages for integrating options for property management. Most of the information has come from the monsoon tallgrass in the Northern Territory, the tropical and sub-tropical tallgrass in eastern Queensland, and the tussock grasslands and *Acacia* shrublands of inland Queensland; the *Acacia* shrublands have been described by Harrington *et al.* (1984) and the other vegetation types by Mott *et al.* (1985).

Effects of management on vegetation and animal production

Stock management

This involves control of the type of animal (which species, breed or class), stocking rate (how many), grazing system (when) and fencing and water supply (where).

Type of stock. Throughout much of northern Australia beef cattle are the only important domestic grazing animals but sheep are also important in some areas, particularly in central and western Queensland. In areas where it is possible, grazing more than one type of livestock together, may be more productive than grazing each type separately. For example, in the *Acacia* shrublands grazing cattle and sheep together is more economically viable than cattle or sheep alone (W.E. Holmes, personal communication).

Goats have often been suggested to control undesirable woody weeds (e.g. Radcliffe 1984). However, evidence in northern Australia suggests that goats, in the absence of other forms of woody weed control are ineffective against *Acacia nilotica* in tussock grassland (J.O. Carter, personal communication) or against woody weeds in *Acacia* shrubland (R.G. Silcock, personal communication).

There has been a large introduction of *Bos indicus* cattle into the northern Australian herd during the last 30 years, e.g. in Queensland the proportion of *Bos indicus* cattle increased from less than 10% in 1960 to almost 80% in 1987; the figure is higher still in the northern region. *Bos indicus* cattle have enhanced performance due to greater resistance to heat stress, cattle ticks and parasites, increased foraging ability, and higher feed intake (Frisch and Vercoe 1977; Siebert 1982). As mentioned later, these characteristics have been implicated in changes to land condition (Gardener *et al.* 1990).

Stocking rate. Stocking rate is a particularly important management variable since it influences animal production and profitability, and is also an important factor in degradation. Production per animal (Jones and Sandland 1974) and feed availability decrease as stocking rate increases; basal area and herbage cover also generally decrease. The general change in botanical composition (Table 1) is for a decline in the proportion of perennial, palatable, grazing-sensitive, tussock grasses and an increase in the less palatable and/or prostrate perennial grasses, annual grasses and dicots (and woody weeds) as stocking rate increases (Arndt and Norman 1959; Tothill and Mott 1985; Gardener *et al.* 1990). In north-east Queensland, heavily grazed areas which were previously dominated by *Heteropogon contortus* have been invaded by the stoloniferous grass *Bothriochloa pertusa* which now forms near mono-specific swards over a large area. In an analogous situation in parts of south-east Queensland, *Heteropogon contortus* has been replaced by another stoloniferous grass, *Digitaria didactyla*.

In all these grasslands few seeds of the major perennial grasses occur in the soil and these seedbanks are transient (Thompson and Grime 1979) and mostly exhausted in the next wet season (Mott

Table 1. Important herbaceous species which 'decrease' or 'increase' in pastures which are heavily utilised. There is a lower proportion of 'decreaser' species in the herbage in heavily utilised pastures than in lightly utilised pastures, and vice versa for 'increaser' species.

Vegetation	Decreaser	Increaser
Monsoon tallgrass e.g. Katherine (14°S; 132°E AAR = 972 mm)	*Themeda triandra* *Sorghum plumosum*	*Chrysopogon fallax* *Brachyacne convergens* *Aristida hygrometrica*
Tropical tallgrass e.g. Charters Towers (20°S; 146°E AAR = 658 mm)	*Themeda triandra* *Heteropogon contortus*	*Bothriochloa pertusa* *Eragrostis* spp. *Sporobolus australasicus* *Tragus australiana*
Sub-tropical tallgrass e.g. Gayndah (26°S; 152°E AAR = 730 mm)	*Themeda triandra* *Heteropogon contortus* *Bothriochloa bladhii*	*Aristida* spp. *Digitaria didactyla*
Tussock grassland e.g. Blackall (24°S; 145°E AAR = 525 mm)	*Astrebla* spp. *Dichanthium sericeum*	*Iseilema* spp. *Amaranthus mitchellii*
Acacia shrubland e.g. Charleville (26°S; 146°E AAR = 498 mm)	*Thyridolepis mitchelliana* *Monochatha paradoxa*	*Aristida* spp. *Tripogon loliiformis*

et al. 1985). Seed numbers would be lower at higher stocking rates where there is a smaller proportion of these species in the herbage.

Little is known of effects of stocking rate and induced changes in pasture condition on herbage quality but overseas studies suggest quality of the available herbage may not decline and may improve at high levels of utilisation (Danckwerts 1989; Heitschmidt *et al.* 1989)

Grazing system. There has been little study of rotational grazing in northern Australia. What little evidence there is (Roe and Allen 1945; Norman 1960; Winks 1984) suggests animal production will be similar or poorer for rotationally grazed animals than continuously grazed animals. Any changes from continuous grazing are likely to be on the basis of improvements in vegetation rather than current animal production, e.g. to improve seedset by perennial grasses. The perennial grasses appear to be most susceptible to heavy grazing at the start of the growing season and there have been suggestions (e.g. Mott 1987; Andrew 1988) that spelling at this time may achieve desirable changes to pastures but these suggestions have not been tested. In a grazing trial at Brian Pastures from 1960 to 1985, *Heteropogon contortus/Bothriochloa bladhii* pastures were grazed at low (0.74 weaners/ha), medium (1.24) or high (2.47) stocking rates in either summer or winter. These pastures were susceptible to heavy grazing in summer but not to heavy grazing pressure in winter (Scattini 1973). (Subsequently, there was a trend for the botanical composition to revert towards the original when heavy grazing in summer was changed to heavy grazing in winter).

Fencing and water supply. These are essential for control of animals. Provision of permanent water supplies is usually the first priority for property development to increase animal survival during drought. Strategic location of waters allows all areas of a property to be used not only those close to natural water. Where properties consist of contrasting land classes, the different areas should be fenced separately since stock concentrate on preferred areas which can suffer from overgrazing even though the rest of the area is not affected. Location of fences is less important in uniform landscapes, e.g. Mitchell grass.

Changes in vegetation characteristics with distance from watering points are often observed (e.g. Andrew and Lange 1986). Common changes are an increase in bare ground and weeds, and a decline in perennial grasses with proximity to water points.

Fire

Fire has been the most widely used management tool (particularly in the higher rainfall areas) and is used for a variety of reasons (Tothill 1971; Anderson *et al.* 1988). Animals grazing burnt pasture usually grow faster during the early wet season (Norman 1960; Ash *et al.* 1982; Winter 1987) due to higher quality pasture available and higher diet quality. Animal performance later in the year may be poorer (Ash *et al.* 1982; Winter 1987) and there can be considerable variation from year to year (Tothill 1983). Effects of burning on subsequent pasture growth have varied but burning reduces the amount of available herbage in the short term and can cause feed shortage.

The perennial grasses have evolved under exposure to fire and all survive although species with shallow roots or above ground growing points (e.g. *Themeda triandra* and *Sorghum plumosum*) are more affected by wet season fires than species with deep roots and sub-surface growing points (e.g. *Chrysopogon fallax*) (Smith 1960). Paton and Rickert (1989) showed spring burning, followed by resting, will increase the proportion of spear grass (*Heteropogon contortus*) and reduce wiregrass (*Aristida* spp.).

Fire is commonly used to control unwanted woody plants and unburnt areas often develop a shrub layer. Hodgkinson and Harrington (1985) have set out the case for using fire to control shrubs in the semi-arid woodlands and a similar rationale should apply in the tropical woodlands. Although regular burning can control some *Eucalyptus* and *Acacia* spp. in the subtropical tallgrass region (C.J. Paton, personal communication), little is known about the effects of fire on many woody plants.

There are also disadvantages of using fire, particularly at high frequency. Nutrients are lost to the atmosphere, feed shortages may be created if dry conditions follow burning and stocking rates are high, undesirable composition changes may occur, e.g. *Acacia* germination may be stimulated leading to dense seedling stands. The reduced cover associated with the reduced herbage levels may predispose an area to increased soil erosion.

Feed supplements

Feed supplements (nitrogen, energy, minerals) are fed to improve the nutrient status of animals to increase growth, reduce weight loss, improve breeding performance, or to prevent mortalities. Part of the improvement in animal production is due to an increase in herbage intake. Winter (1988) estimated intake increased by 20-40% when animals grazing stylo-native grass pastures near Katherine were supplemented with phosphorus and this was reflected in reduced pasture availability and a decreased proportion of perennial grass in the pastures. This increase in grazing pressure must be considered when supplements are used.

Timber treatment

Trees compete with herbaceous species for water and nutrients and killing or removing trees can increase the yield of herbage. There is a curvilinear relationship between herbage yield and tree density (Scanlan and Burrows 1990) and the effect of a given tree density increases as soil fertility and rainfall decrease. The responses to tree removal vary geographically. In south-east Queensland dry spells are frequent during the growing season and twofold increases in herbage production following tree removal are common; animal production per head increases and carrying capacity is also higher. In north-western Australia where such dry spells are less common, Winter *et al.* (1989) found yield responses were smaller, grass quality was not affected and benefits to animal production were confined to reduced weight losses during the dry season. In north- eastern Australia, Gillard (1979) showed significant herbage responses to tree killing in all years with an average increase of 77%. In dry years, weight losses during the dry season were lower and weight gains during the wet season greater, where trees were killed. In wet years there were no differences in weight change during the wet season and the benefits to tree clearing during the dry season were smaller.

There are also negative effects of tree clearing. Clearing trees can produce a range of hydrological responses but unless the water extraction by the new vegetation is identical to that of the original woodland there will be changes. Water that is not used by vegetation will move beyond the root zone and into the groundwater. Salt may accumulate in the groundwater and streams, or in the soil where the water table reaches near the surface. There is an urgent need to determine which areas will be prone to salting so clearing can be avoided. Steep slopes and unstable soils may be more prone to erosion after clearing. Killing or removing mature trees "releases" suppressed seedlings and appears to make areas more prone to shrub invasion. Such changes can reduce the benefits of improved herbage production.

Effects of management on soil characteristics

In contrast to the situation with vegetation and animal production, there have been few detailed studies of the effects of management on soil characteristics. Mott *et al.* (1979) and Bridge *et al.* (1983) described the development of soil seals in monsoon tallgrass pastures at Katherine where the perennial grasses were destroyed or weakened by heavy grazing. Solodic soils in the poplar box lands become compacted with grazing resulting in reduced infiltration and scalds develop where grass recruitment is prevented (Tunstall and Webb 1981). Water extraction from the soil can be reduced when trees are killed (Gillard *et al.* 1989), resulting in an accumulation of water at depth and a redistribution of soluble salts (Tunstall and Webb 1981; Gillard *et al.* 1989). Studies have been conducted in recent years in the Burdekin catchment (McIvor *et al.*, unpublished data; A.J. Pressland, personal communication) including a current study of the structure of soil animal and microbial populations in degraded and non-degraded soils (J.A. Holt, personal communication). Soil biology has received little study in the past and biological changes may be of particular importance in soil degradation.

Burdekin catchment: animal and pasture effects

The upper Burdekin River catchment provides an example of how management decisions and seasons interact to influence pasture condition. The area was settled in the 1860s. After a brief period of sheep grazing, cattle raising became the dominant industry. For the first hundred years light stocking with British breed animals was the norm and apart from some frontage country, pastures remained in good condition although there were changes in botanical composition. However, the situation has changed markedly since the 1960s. There has been a marked increase in the proportion of *Bos indicus* cattle and also much more supplementary feeding. Cattle numbers in the Northern Statistical Division (the majority of which are in Dalrymple Shire) averaged approximately 0.5 M from 1940 to 1970 but then increased to more than 1M from 1977 to 1979. The cattle numbers and feed supply were in approximate balance prior to 1970 (Pressland 1990) but since 1975 there has been a marked increase in grazing pressure. This resulted in a widespread reduction in available herbage and ground cover with consequent fears of large soil erosion losses. With improved seasons in 1989 and 1990 and a large reduction in animal numbers there has been widespread recovery although much of the grass cover is less than desirable.

Role of decision support systems

Management decisions at the property or regional level involve many complex and inter-related issues. For example, stocking rate and frequency of burning need to be considered against a background of variable seasonal conditions and prices for products (McKeon *et al.* 1990). Decision support systems can provide valuable assistance in guiding management decisions because they are based on both research and practical experience. GRASSMAN (Scanlan and McKeon 1990) is a decision support system which allows management decisions to be evaluated e.g. timber clearing, burning and stocking rates in relation to trends in seasonal rainfall or pasture production. The combination of decision support systems and anticipated improvements in seasonal weather forecasting based on changes in the Southern Oscillation Index (Coughlan 1988) should improve the efficiency of decision making and ensure land use is realistically aligned with the long term sustainability of the soil and vegetation resource.

Priorities for future research

1. There has been only limited study made of the ecology of the important species. This is particularly so for the dynamics of these species and such knowledge will be important for determining suitable management procedures to change vegetation composition, e.g. Orr (1988), Howden (1988).

2. There are increasing numbers of woody plants in grasslands in northern Australia, both native and introduced. The biology of these invasions is likely to be similar to that outlined for the semi-arid woodlands by Hodgkinson and Harrington (1985), but there is need for studies of the characteristics of important species and their responses to management, e.g. fire, grazing pressure. A related area of woodland management requiring attention is the need to be able to predict areas prone to salting if trees are killed or removed.
3. The research to date has not covered all vegetation types in detail. An important omission is the *Aristida/Bothriochloa* zone in inland Queensland. Also, the vegetation types are not uniform, and variation between sites within a given vegetation type must be considered.
4. In areas with such variable rainfall as northern Australia, overgrazing is likely at some times. There is a need to determine the potential to rehabilitate overgrazed areas, the means and costs of doing so, and also the cost of such overgrazing in terms of reduced future production e.g. Orr *et al.* (1990).
5. Until recently there were no long term trials examining the effect of continuous grazing at different stocking rates on these pastures. Studies have been made of different utilisation rates on both Mitchell grass and mulga lands (Orr *et al.* 1991). Trials have recently commenced in the tropical and subtropical tallgrass zones but there are no such trials in the monsoon tallgrass despite their known sensitivity to increased grazing pressure. Such trials are an ideal location for ecological studies (point no. 1).
6. Manipulating grazing systems (resting, deferring, heavy grazing) has been suggested but infrequently tested for changing pasture composition and animal production. Such systems may have value for improving or maintaining animal production and also for rehabilitating degraded areas (point no. 4).

In all these areas, information is required on effects on soils, vegetation and animals. Future research will need to involve all aspects of farming systems with a balance between increases in short term production and effects on soil and vegetation resources. Both must be considered if we are to manage our grasslands for profitable animal production without land degradation.

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