MANAGEMENT OF AUSTRALIAN SAVANNAS

W. H. BURROWS*, J. G. McIVOR** and M. H. ANDREW+

* Department of Primary Industries, Rockhampton, Queensland 4700.
** CSIRO, Davies Laboratory, Townsville, Queensland 4814.
\+ CSIRO, Darwin Laboratories, Winnellie, Northern Territory 5789.

ABSTRACT

The role of management in minimizing animal production constraints in Australia's savanna regions is considered. Particular attention is given to ways of improving herbage quality and to optimizing the tree-grass balance. The potential instability of savanna systems is highlighted by the current invasion of Mitchell (*Astrebla* spp.) grasslands by *Acacia nilotica* and also the loss in grass cover which can accompany intensification of use in northern areas. Further research, within the framework of integrated property management, is suggested to overcome these problems.

INTRODUCTION

Savannas include all tropical regions of the world which experience strongly alternating wet and dry seasons and which in their natural state have a continuous cover of tropical (C_4) grasses and a discontinuous overstorey of woody plants. Recent reviews of savanna systems can be found in Walker (1979), Huntley and Walker (1982), Bourliere (1983), Sarmiento (1984) and Tothill and Mott (1985).

Australian savanna lands cover about 200 million ha (Mott *et al*. 1985). These authors recognise six major savanna types - monsoon tallgrass, tropical tallgrass, sub-tropical tallgrass, midgrass, midgrass on clay soils and tussock grasslands. However we extend the midgrass type of Mott *et al*. (1985) to include the large area of eucalypt 'desert' woodlands, with a prominent *Aristida*-*Triodia* understorey, in central western Queensland.

Although mining, crop production and tourism are important pursuits (Young 1984), pastoralism is the major land use of Australian savannas (Weston *et al*. 1981). In this paper we consider how management can overcome or minimise the constraints to animal production that occur in savanna regions.

MANAGEMENT OPTIONS TO OVERCOME/MINIMIZE PRODUCTION CONSTRAINTS

The savanna regions are characterised by large properties with low turnoff rates, while low financial returns and large capital and maintenance costs limit the options available to managers. The initial priorities of management are to provide permanent water and fencing. Even so, as recently as 1979 lack of water was considered a problem over 25% of stations surveyed in the Victoria River district (Robertson 1980). Further inputs, in a range management context, are the use of fire and tree thinning or removal (Tothill *et al*. 1985). However, the latter authors note that the ultimate limitation in livestock productivity of native savannas lies in the poor quality and/or quantity of herbage.

Herbage quality

Herbage quality is seldom high in savanna regions. Apart from soils supporting inland tussock grasslands and *Acacia* shrublands, the soils generally contain low levels of nitrogen and phosphorus. Rainfall throughout the region is strongly seasonal with seasonality increasing from the southern sub-tropics to the north-western tropics. The low soil fertility and the good growing conditions (high temperature and moisture availability) during the wet season combine with the high potential growth rates of the C_4 grasses to produce herbage with low digestibility and nutrient concentrations below the level necessary for liveweight maintenance (Siebert and Hunter 1977, McIvor 1981). In southern areas low winter temperatures are an additional constraint to growth (Fig. 1) and hence contribute to low herbage quality since animals must rely on accumulated, senescing material.

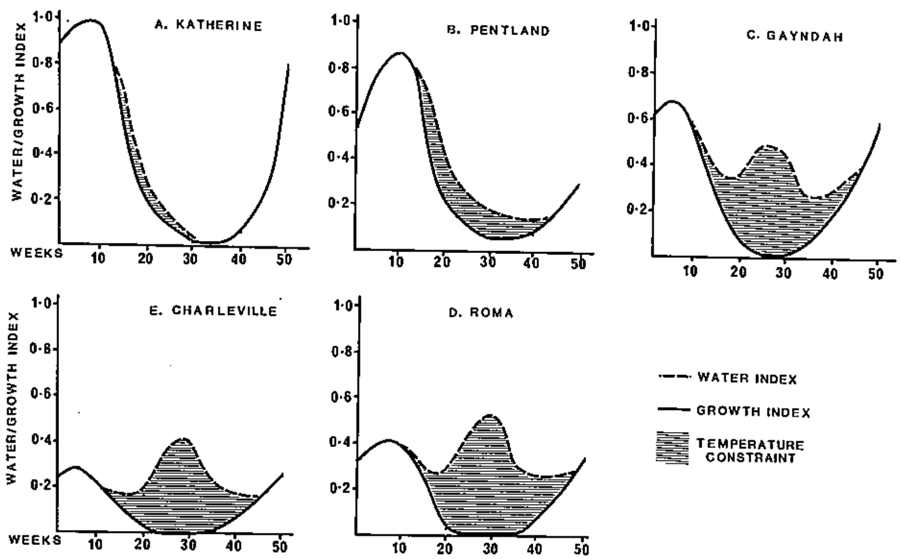

FIGURE 1

The water index/growth index and temperature constraints for tropical (C_4) grass growth as a function of week number commencing in January each year for five locations in the Australian Savanna. A = Monsoon Tallgrass savanna, B = Tropical Tallgrass savanna, C = Subtropical Tallgrass savanna, D = Midgrass on clay soils, E = Midgrass savanna (after Mott *et al*. 1985).

Given these aforementioned constraints management options to improve the quality of animal diets include:

Oversowing legumes Oversowing legumes into native pastures can raise the nutrition of grazing animals and has been used experimentally and commercially, e.g. Edye and Gillard (1985). Species in the genus *Stylosanthes* are the most suitable legumes over wide areas although *Macroptilium atropurpureum* is important in central and south-east Queensland.

Gillard and Winter (1984) reviewed the results of animal production studies on stylo-based pastures. Carrying capacity of pastures is increased by oversowing with stylo although production per head may be little different to that on native pasture unless superphosphate is applied.

Supplementary feeding Supplements (urea, molasses, minerals, grains, etc.) are used to overcome dietary deficiencies in the pastures in some areas. Feeding of urea/molasses during the dry season can decrease mortalities and produce liveweight responses (Winks 1984) and phosphorus supplementation can also give large animal liveweight gains (Winter 1983b). Pen feeding studies have shown animals supplemented with urea can consume up to 65% more low quality herbage (Ernst *et al*. 1975) and Winter (1983b) found higher levels of pasture utilization when animals were supplemented with phosphorus. Access to fodder crops, crop stubble or sown pasture can also provide important adjuncts to animal diets on properties with a mosaic of arable land, as well as native pasture.

Shrub legumes In the central and south-eastern regions there may be large amounts of soil water available which are not being utilized by the temperature limited C_4 grasses. This moisture can be utilized by deeper rooted shrub legumes (e.g. *Leucaena leucocephala*) to produce high quality feed during the cooler months of the year.

Water ponds for grasses The use of natural swamps or constructed ponds to store water during the wet season and the establishment of grasses which will grow in shallow water (e.g. *Brachiaria mutica*) produces green feed as water recedes during the dry season.

Herbage quantity

Throughout most of Australia's savannas herbage quantity has generally not been limiting, since the low quality necessitated low stocking rates so animals could select as high a quality diet as possible from the nutritionally poor herbage. However the introduction of *Bos indicus* stock, the oversowing of legumes and the provision of supplements overcomes this limitation and herbage quantity is becoming a constraint over increasing areas. Three options are available to managers to minimize this problem; reduce stock numbers, add grazing tolerant species which will replace or re-inforce the native species, or reduce tree densities where appropriate.

Fire

Fire has been a major determinant of the natural vegetation of savanna lands and is important in maintaining the tree-grass balance. The high fire frequency in the wetter savanna regions aids in suppressing the regeneration of the tree layer (Bell 1981), although this is not so critical in the drier situations (Andrew *et al*. 1985). In the semi-arid savannas there is a reluctance to use fire, because graziers do not favour the removal of dry herbage which, being of relatively higher quality, may be an important reserve in time of drought. However in wetter regions, the use of fire is widespread. Since the vegetation is highly combustible during the late dry season fires will eventually occur from accidental or natural causes. To prevent these potentially disastrous events burning is a regular management tool. Fire makes any young regrowth more available to grazing animals in addition to reducing the fuel load. It can also be used to control the distribution of grazing cattle, since cattle preferentially graze the burnt areas while leaving unburnt areas spelled. Although there have been many studies of the effects of fire on the vegetation, studies of fire effects on animal production are few and responses have ranged from negligible at Swan's Lagoon (McLennan et al. 1985) to 8-16 percent/annum at Narayen (Tothill 1983b). The interaction of fire and stocking rate effects can be particularly important in these situations.

Tree-grass balance

Tree densities in Australian savannas range from high (>500 per ha) where they grade into forests to very low (<5 per ha) in some inland, tussock grass areas. In contrast to many overseas savannas, the dominant native species in Australia are inedible and make little contribution to animal nutrition although they probably play an important role in nutrient cycling.

On a world scene the subject of the tree-grass balance has been addressed by Walker and his co-workers (Walker 1980, Walker et al. 1981, Walker and Noy-Meir 1982, Knoop and Walker 1985) largely based on the simple description of competition for water represented by Walter's two layer hypothesis (Walter 1971). This proposes that adult trees and grass compete for water in the surface layers of the soil, but woody vegetation has exclusive access to moisture in the deeper sub-soil. Mott et al. (1985) claim this partitioning does not seem clearly defined in Australian savannas, where the soil moisture depth is often limited by either the shallowness of the major soil groups or by an impermeable layer of different texture or high soluble salt. Nevertheless Walter's viewpoint provides a useful framework for discussion of competition between woody plants and graminoids in Australia, as in savannas elsewhere. The advantages of exploiting sub-soil moisture are clearly demonstrated by many trees in northern Australia which produce new shoot growth some weeks before the start of the wet season (Specht and Brouwer 1975).

Tree density is determined by the dry season 'carrying capacity' for trees based on the soil moisture store in that part of the profile available only to the trees (Mott and Tothill 1984). Thus the degree to which trees compete with one another is suggested by their spacing under natural conditions. Trees and herbage compete for water only when both are actively transpiring. Since in the dry season the herbaceous species are dormant through dryness of the root zone (tropics) and/or low minimum temperature (sub-tropics), competition will only occur during the wet season (Mott and Tothill 1984).

Research in a variety of environments has now shown that quite low tree densities can reduce pasture yield (Walker et al. 1972, Beale 1973, Gillard 1979, Tothill 1983a, Scanlan 1984, Winter et al. 1985). The effect of a given number of trees increases as fertility and rainfall decrease (Burrows et al. 1986). In the northern zone there is usually enough moisture to satisfy the needs of both trees and grass during the wet season. Hence, Gillard (1979) only reported improved animal production in dry years at Kangaroo Hills and Winter *et al*. (1985) suggest the practice does not result in improved pasture quality or live weight gains in the north-east, although there may be slightly higher carrying capacities.

In the south-east sub tropics summer rainfall is not so prolonged and is frequently interrupted by dry spells which result in trees being very competitive with the associated herbage for soil moisture. Thus Tothill (1983a) obtained a two-to three-fold increase in beef production per head and per ha from clearing silver leaf ironbark woodland in south-east Queensland.

Grazing can have a marked but variable effect on the tree-grass balance. Noy-Meir (1982) noted that heavy fixed herbivore pressure can kill the perennial grass and convert savanna into a dense woodland. However Tothill (1971) and Burrows *et al*. (1986) observed that grazing can also reduce the establishment of savanna trees. Regenerative powers of savanna trees and shrubs are well demonstrated following mechanical disturbance of savanna soils. On balance, the general result of man's disturbance of savanna lands, other than for complete replacement of vegetation, has been to increase the density of woody plants. Redressing this problem requires much 'follow-up' treatment. Therefore Burrows *et al*. (1986) propose that tree clearing south of 20°S latitude should be on the basis of complete clearing, while leaving untouched strips and clumps covering up to 20% of the total area. This maximises pasture production, minimises regrowth, provides the best shade, shelter and fire breaks and also is more acceptable for wildlife conservation. Clearing is not recommended along creeks and water courses, on slopes >20% or where salting problems could result from rising water tables.

In the initially treeless Mitchell grasslands of north-western Queensland and the Barkly Tablelands, lack of shade has constrained animal production. As in other savanna areas herbage quality is low during the late dry season and to overcome these two constraints, the exotic thorn tree *Acacia nilotica* has been planted along bore drains and around earth tanks. From there it is now actively invading the grasslands. This situation is of considerable concern even though at low densities *A. nilotica* improves animal production by providing shade and a valuable protein source in the late dry season.

Ripening *A. nilotica* pods are relished by cattle and sheep in the nutritionally critical September-December period. *A. nilotica* can produce up to 150 kg of pods per tree (Anon. 1977) which contain about 1×10^6 seeds. Approximately 40% of seed ingested by cattle passes through the animal and is germinable, compared with 0.15% for sheep (Harvey 1981). Thus cattle are powerful dispersal agents and the sequence of favourable rainfall years in the 1970's further encouraged germination and successful establishment. The time scale for development of a closed canopy stand, with initial seed sources from plants on bore drains, seems to be about 30 years (W.E. Holmes pers. comm.). These observations are supported by African experience where cattle do not inhibit the regeneration of thorny woody plants (Taylor and Walker 1978) and, if anything, increase the rate of dissemination of seeds and pods (Walker *et al*. 1981). Also, in savanna where *Acacia* spp. are common, enormous quantities of quiescent seed are present, and establishment of seedling acacia plants, especially after disturbance or clearing, is a recurring problem (Barnes 1982).

The long term viability of the grazing industry in the Mitchell grasslands is therefore under serious threat from Acacia nilotica, more so since initial infestations enhance financial returns to graziers (W.E. Holmes unpublished). Hence we need to consider alternative uses for any converted grasslands. In Africa moderately dense tree-shrub savanna would be stocked with goats or with one or more selected wild browsing ungulates such as eland, kudu and giraffe, or the intermediate feeding impala (Barnes 1982). The speed of invasion of Mitchell grasslands by Acacia nilotica is such that the feasibility of alternative livestock enterprises needs researching now. In the meantime the exclusion of cattle, at least during the period ripe seed is on the trees would retard seed dispersal.

DISCUSSION

Savannas are not noted for their stability, although there are many homeostatic mechanisms which usually prevent changes of too great a magnitude. Walker and Noy-Meir (1982) suggest that it can be self defeating to attempt to protect savanna systems from disturbance e.g. protecting a system from fire simply leads to increasing fuel loads until a fire inevitably does occur with devastating intensity. Similarly they note that some of the worst examples of savanna degradation have resulted from attempts to decrease spatial variation by the introduction of artificial water supplies, fencing etc. In general this has resulted in an increase in the ratio of trees (and shrubs) to grass.

One of the most notable changes in the beef industry in the last 25 years has been the rapid incorporation of Bos indicus genes into the northern herds. B. indicus cattle were first introduced in 1933 but by 1961 only 10% of Queensland cattle had some B. indicus content (Anon. 1962); this figure is now greater than 70% and in coastal northern Queensland it is more than 90% (Anon. 1983). This change in breed composition has been accompanied by an increase in herd numbers (5.8 M in 1961 to 9.0 M in 1983). The B. indicus cattle and their cross-breds have higher growth rates and survival rates than the British breeds (Winks 1984) and this, combined with the increased herd numbers, has increased the grazing pressure on the pastures. In above-average seasons this increased grazing pressure may have little effect on animal production since herbage quality is the limiting factor. However, in drought years there are serious effects when available herbage is limiting (e.g., Shaw and 't Mannetje 1970).

Throughout the savanna lands herbage quality has in the past acted as a natural regulator, with animal mortality restricting grazing pressures to levels that are safe for the majority of native pastures (Mott et al. 1981). Most damage to herbage plants occurs not through excessive grazing in the dry, but through too great a grazing pressure in the early wet (Mott 1985) as plants are rebuilding reserves and setting seed. This effect is accentuated by technological improvements such as the introduction of better adapted stock, supplementation with urea/molasses etc. and oversowing with legumes, which all increase grazing pressure on pastures and enhance drought survival for the stock.

There has been little detailed study of the effect of increased grazing pressure on native pastures. However, general observations are similar to those of Shaw and 't Mannetje (1970)- a reduction in the number and size of perennial grass plants leading to a reduction in total vegetative cover, an increase in bare ground and an increase in forbs, and also much more variation between years in botanical composition of the pasture (Gardener and McIvor 1985).

Although the stylos are generally tolerant of high stocking rates, the native grass species are much less tolerant particularly in northern areas (Mott and Tothill 1984). Where superphosphate has been applied the native perennial grasses have been replaced by annual grasses (e.g. Digitaria ciliaris and Brachiaria miliiformis), forbs (e.g. Sida acuta) and introduced grasses (e.g. Cenchrus ciliaris and Urochloa mosambicensis) but where little or no superphosphate was used strongly stylo dominant pastures have been produced at a number of locations : Katherine (Winter 1983a), Wrotham Park (Edye and Gillard 1985), Lansdown (Gardener and McIvor 1985), and Swan's Lagoon (Winks 1973). With high levels of pasture utilization, little legume remains at the end of the dry season and these stylo dominant areas may be prone to soil erosion during the early wet season.

Mott and Tothill (1984) have suggested the lower tolerance to grazing shown by native perennial grasses is due to the more severe environment of the region compared with the sub-tropics. The yield of the sown legumes may also be important. A high yielding legume will compete more effectively and since cattle prefer grass to legume during the early growing season (Gardener 1984), a higher yielding legume will increase the grazing pressure on the smaller amount of grass remaining at a time when the grasses are particularly susceptible to defoliation (Mott and Tothill 1984). This was demonstrated at Kangaroo Hills where S. humilis-based pastures (legume yield usually <1,000 kg/ha) remained c. 80% native grass while in similarly treated S. hamata-based pastures (legume yield up to 6,000 kg/ha) the native grasses declined to c. 10% over 5 years (Gillard et al. 1980).

Another consequence of the increased grazing pressure will be a reduction in the frequency of fires. In the past, many of the tropical woodlands have been burnt every 1-3 years. The reduction in fire frequency has been implicated in the increase in shrubs in western New South Wales, and it is possible a similar situation could develop in northern Australia.

Since there are many alternative pathways to develop and manage these fragile ecosystems, it is important that research in the region is conducted in an integrated framework of the whole system which consideres ecology and agronomy, animal production, sociology, economics and practical management. Areas requiring further research include:

Monitoring of soil and vegetation changes With intensification due to the brucellosis and tuberculosis eradication campaign in cattle herds, the introduction of legumes and the use of supplements, large changes can be expected and it is important these be detected early and documented.

Level of utilization As levels of utilization increase there will be an increased need for knowledge of pasture ecology (rates of degradation, characteristics of degrading pastures, usefulness of spelling pastures, weed invasion, regeneration of degraded areas), animal production, soil erosion and the economic viability of pastoral operations.

Tree-grass balance Man's interference with savannas has generally resulted in an increased ratio of woody to herbaceous species and there is a lack of knowledge of tree/shrub/grass interactions under different grazing/fire regimes.

Management options More studies are needed on the selection and establishment of suitable introduced species, the fertilizer/supplement requirements for animal production in both native grass and stylo based pastures and on the integration of sown and native pastures.

CONCLUSIONS

Development pathways in Australian savanna should be low cost and require minimal maintenance. This means that native vegetation will remain the region's basic resource, and while this may be augmented it will rarely be completely replaced. Vegetation management should initially aim at obtaining the optimum tree-grass balance since the ultimate stability of savanna lands depends on control of the tree population. This means substantial reductions in tree populations south of *c.* 20°S latitude but little modification in the highly summer rainfall dominated northern savannas. The benefits of fire to animal production are somewhat equivocal throughout the savanna zone, even though these are naturally fire prone systems.

Additional inputs from improved pasture or supplements should focus on overcoming dietary deficiencies common in the dry season. However this has the concomitant effect of increasing normal stocking pressures at the commencement of the wet season, with a resultant detrimental effect on native pasture stability. There is a case for the development of special purpose pastures to reduce the stocking pressure on the native systems at this time.

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