Sustaining productive pastures in the tropics 11. An ecological perspective

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Abstract

Opportunities for continued utilisation of Australia's tropical pasture systems are explored and some of the ecological constraints leading to breakdown of the systems discussed. The need to evaluate basic range management concepts for managing the extensive areas of native and naturalised pastures is highlighted.

Resumen

Se exploran las oportunidades de una utilización continua de los sistemas de pasturas de Australia y se discuten algunas de las limitaciones ecológicas que conducen al rompimiento de los sistemas. Se recalca la necesidad de evaluar los conceptos básicos de manejo de pastizales para manejar las grandes áreas de pasturas nativas y naturalizadas.

Introduction

There are few pastures in the tropics and subtropics in equilibrium with their management. The productivity of many systems has improved substantially as a result of research and development, but it is equally true that production from others, both native and introduced, has declined. In most cases man and his animals have had a dramatic impact on the dynamics of these communities, over and above climatic influences.

Two important principles underpin the sustainability of pasture systems — first, the need to maintain the integrity of the soil resource and second, the need to apply conservative grazing management. Sustaining productive pastures is about utilising species that are in tune with the management imposed on them (or adjusting it accordingly), as well as ensuring that the species 'fit' the ecological niche available in the system.

Sustainability is also about recognising the triggers that initiate change and the events that indicate them. These are the times when management is most critical. For example, changes may come with above average autumn rains, which promote widespread woody weed establishment; with good summer rains, which permit managed burns in the following spring; or the confluence of favourable seasons and high product prices, which might allow inputs such as fertilizer. Finally, sustainability has to be judged over a realistic time frame which normally would encompass a wide range of climatic events.

The preceding papers in this issue of Tropical Grasslands recognize these essentials, while acknowledging the real potential to improve the productivity of tropical pastures by a variety of available and well researched technologies. Nevertheless, the enthusiasm of earlier generations of pasture scientists has now been tempered by a better appreciation of what is achievable in tropical pasture research and development.

Soils

Soil is the basic resource of all pasture systems. Vegetation is usually resilient if the original soil supporting it remains intact, but a degraded soil lowers the productivity of the system indefinitely (Harrington *et al.* 1984). Soil is especially vulnerable to degradation where the nutrient pool is concentrated in the surface horizon.

Concern has been expressed in some quarters over the diminution of soil nutrients through marketing of animal products, erosional processes and the removal of trees which act as 'nutrient pumps'. This needs to be put into perspective.

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Consider phosphorus. An adult beast contains c. 3.5 kg of P so that based on a 3.5 year turn-off time and stocking rate of 4 ha/steer animal products remove c. 250 g P/year. This compares with a total soil pool of 2000-4000 kg P/ha to 1 m depth in infertile systems and 'available' P pool sizes of >40 kg/ha. (Note: A P supplement program on 'low' P soils, which aims to give animals, stocked at 4 ha/steer, 5-6 g P/hd/day over a 180 day period, is sufficient to replace the amount of P removed annually in animal products.)

Salt outbreaks are often presented as a serious concern in the north and the possibility of such occurrences arising as a result of management should never be ignored. Nevertheless this problem also needs to be put in perspective. Currently c. 10 000 ha (or <0.007%) of the grazing land in Queensland in seriously affected.

Salinisation is a real concern in temperate Australia while some problems in the south are not applicable in the north (Burrows 1991) for the following reasons:

- in the Mediterranean type climate of the south precipitation often exceeds evapotranspiration during the cool months corresponding with the plant growing season, thus enhancing deep percolation and the mobilisation of incipient salt; the reverse usually applies in the north with its dominant summer rainfall and higher evapotranspiration rates in that growing season. (Will a similar mechanism limit NO_3 leaching and hence the acidification potential of northern pastures?)
- the Murray-Darling river basin is huge, while its southern outlets and flood plains are the funnel through which the dissolved salts of Queensland and New South Wales have been concentrated over eons (Lake Eyre acts as a similar repository in South Australia).
- cyclic salt from the oceans has built up over large areas of southern Australia as a result of the long persistent wind circulation patterns.

The best advice on management of north Australian soils, especially with respect to salting, would seem to adopt the integrated catchment/landscape approach suggested by Williams and Chartres (1991). This is particularly relevant to tree clearing and woodland development which certainly require more careful consideration in their application in the north.

Tree-grass balance

There is no doubt that the past attitude to tree clearing — certainly south of 20 °S latitude — was usually one of unthinking destruction, saved only by the extreme competitiveness and resilience of the woody plants. However, even the best intentioned landholder will have little overall effect on landscape and ecological stability unless his efforts are coordinated with those of similar acting neighbours.

In searching for a desirable balance between trees and pasture it is becoming more and more evident that there are only two stable states in much of the northern native pasture lands — either "all trees" or "all grass". Intermediate states are transient, as has recently been portrayed by Westoby *et al.* (1989). It does not follow that pastoralists should remove all trees and in fact if current QDPI staff guidelines (Burrows 1990a) are adopted the ongoing retention of c. 50% of the woodland resources would be assured; while maximizing animal production and minimizing regrowth problems on the remainder.

The reasons for reducing existing tree and woody weed competition are well covered by Scanlan *et al.* (1991). Scanlan and Burrows (1990) have also noted out that maximum pasture response occurs when trees are removed from 'dry', 'infertile' sites, with the response being less pronounced on moist and/or fertile areas. Nevertheless we should not lose sight of the fact that in removing c. 500 000 ha of trees, regrowth and woody weeds in the tropics/sub-tropics each year an ecological niche is created which can, and should be filled by deep rooted species more suited to animal production than those destroyed.

Fodder trees have obvious benefits but they can also fill many of the roles which conservationists see in trees generally (for example, shade, shelter, nutrient pumps) although some roles (for example, wildlife habitat and timber sources) will usually require indigenous tree retention in other areas, as previously mentioned. However, with increasing emphasis on introduced fodder trees heed should be taken of the warning of Scanlan *et al.* (1991) of the dangers of introducing weedy species (such as the misguided efforts with *Acacia nilotica* in Western Queensland).

Grass and legumes

Grassland management hinges around many issues which determine animal performance (for example, control of stock, fire, feed supplements, legume oversowing, tree-grass ratio etc). The importance of the interaction of these options with each other and the environment (for example, drought) is outlined by McIvor and Orr (1991). Ignorance of such interactions led to the problem of the Burdekin River catchment in the 1980s — as tellingly told by the potential vs actual stocking rate figures prepared by McKeon *et al.* (1990).

Augmenting native pastures with legumes is the 'light on the hill' for tropical pasture science since it unlocks an enormous potential for improving beef production (for example, all of Queensland's 25 million ha of black speargrass lands are suited to this technology). But there are risks — not least the claim by Miller and Stockwell (1991) that sooner or later there will be ever-increasing stocking rates. One may well ask — Why? This will occur if we do not follow up recommendations to oversow legumes with management prescriptions — foremost amongst these is that, in the absence of fertilizer and other grass inputs, stocking rates should not be increased on oversown pastures.

One of the main sources of confusion and dissension with augmentation technology is the large variability in environment and plant responses that are experienced from north to south and east to west (cf. Miller and Stockwell 1991). The lack of winter rainfall and frosts in the north, along with widespread and extreme soil infertility means that grass quickly reverts to supplementing the legume, rather than vice versa. This switch in species dominance occurs at a slower rate in the south, but the still inevitable increase in density of species such as Seca stylo has to be managed. This is because a high legume biomass (>50% composition by weight) exposes animals in frost susceptible areas to the real risk of severe feed shortages in cold, dry winters. Heavy grass utilization in summer to promote establishment of annual medics (Clarkson *et al.* 1991) presents similar risks in the event of poor winter rains.

Shrubby stylos may be small in stature but they are woody plants so the principles underlying the management of Seca-grass mixtures are the same as apply to tree-grass situations — especially where the tree is also a palatable fodder. There are two parallels to draw on in the tropics — subtropics viz. mulga and mitchell grass. In both these communities the grass component has largely disappeared, or is disappearing fast, because a leguminous fodder tree (mulga or *Acacia nilotica*) provides grazing animals with a high quality diet when it would otherwise not be available. As a consequence stock can be maintained well into the dry season and are often present in high numbers at the break of season. Previously, in the absence of these woody leguminous fodder plants many animals may have died or been sent elsewhere on agistment. However grass recovery can be seriously affected if heavy grazing pressure is applied from the outset of the new growing season.

Augmentation of native grass pastures with adapted tropical legumes in the north can draw upon the much wider experience obtained with temperate legumes introduced into tropical grass pastures in the south. Hence the points raised by Clarkson *et al.* (1991) apply equally as a check list of necessary knowledge to ensure sustainable systems are maintained in both situations. One point which particularly needs attention is the necessity to maintain high soil seed banks, especially of annual or weakly perennial legume species. Fortunately, longevity is a feature of most legume seed and if adequate supplies exist in the soil the capacity to recover after the inevitable climatic or management disasters, which forever challenge our pastures, will be more assured.

Fodder trees and shrubs

There are few areas in northern Australia where trees are not potentially the dominant vegetative lifeform — mitchell grassland was once thought a major exception but its ongoing conversion to thorn scrubland has effectively dispelled that belief. The promise of fodder trees is expressed through their ability to tap nutrient and moisture resources not otherwise reached by associated pastures. Their risk has been that they would dominate in analogous fashion to mulga or *Acacia nilotica* — but management should be possible provided the species is palatable, non-thorny and has some susceptibility to fire. In fact as Shelton *et al.* (1991) point out establishment of desired species has so far been more a limitation, than any weed potential.

We should not be afraid to acknowledge our role in reconstructing ecosystems to meet the requirements of man and beast. It is of course the essential art of pasture science — the trick being to match the environmental, production and managerial requirements with the species. There is an enormous gene pool of tree legumes available worldwide awaiting evaluation to fill niches in our tropical pasture systems. It is certainly time to explore this potential in a more reasoned and systematic way than has been done in the past. Shelton *et al.* (1991) note the environmental benefits of planting tree legumes and this should not be lost on an industry and profession under increasing pressure from the "green" lobby.

Introduced grass pastures

Herbaceous and tree legumes already give us substantial improvements in animal production and they have an even more exciting future. Nevertheless the greatest additional impact on animal performance from introduced species in the tropics so far has come from sown grasses — especially buffel grass, green panic and Rhodes planted on brigalow and gidgee scrub soils. These species were outstandingly suited to exploit the N build-up associated with the evolution and subsequent clearing of these woodlands. But most of those pastures are now over 20 years old and animal production is well off the initial peaks which followed ash-bed sowings.

The assessment of run-down in these pastures by Myers and Robbins (1991) is realistic and refreshingly honest. By recognizing that 'the run-down condition is the normal equilibrium condition' they have taken the essential first step to managing the situation. The easiest management option is to accept the lower per hectare productivity brought about by lowering stocking rates and this in turn will allow individual animal performance to be maintained near original levels (LWG of c. 180 kg/hd/yr).

Johnson and Tothill (1985) have pointed out that the nitrogen demanding Panicoid genera (for example, *Panicum, Cenchrus*) will tend to be replaced in derived savannas by less demanding Andropogonoid genera (for example, *Bothriochloa, Dichanthium*). An intermediate step in this process may well be to introduce a legume (such as *Stylosanthes* or *Desmanthus* spp.) into the grass pasture. Such introduction is actually facilitated by the 'run-down' of the grass, which reduces its competitiveness. In particularly well favoured sites (deep calcareous soils, high P levels) the introduction of *Leucaena* has even reversed the process. But the longer term future of many of these induced grasslands could well lie in letting the N demanding species be naturally or intentionally replaced by Andropogonoid and/or Chloroid species.

It is unlikely that introduced grass pastures in the drier inland could ever be economically maintained in a highly productive state by N fertilizers. However Teitzel *et al.* (1991) point out two very useful roles for N fertilized pastures —

(i) in increasing the sustainability of companion pastures by enabling pressure to be taken off them at critical times (for example, at the end of the dry season) and;
(ii) boosting production of beef or dairy cattle to suit or meet market demand and so increase profitability.

As noted previously grasses vary in their fertility needs so that N fertilizer applied in these situations should at least target N responsive species. This would rule out its application to native pastures.

Stocking rates

The previous concepts are closely aligned to a key feature of sustainable pastoralism — this is to adjust stock numbers to the feed available. By using special purpose pastures to relieve stocking pressure on other areas at times of feed shortage, it is conceivable that overall carrying capacities could be increased realistically. (Ponded pastures may not fill this role because they can be inundated at the break of season.) Thus a common frustration of graziers in variable climates — the need to determine stocking rates by the number that can be safely carried in the 'dry' season — could be alleviated. Meanwhile an alternative suggestion has been made by Stockwell *et al.* (1991) who strongly favour reducing stocking rates to increase efficiency and individual animal performance, decrease pasture utilization and lower enterprise risks.

For many years economists have told us that it is live weight gain per hectare rather than per animal that influences property profitability. An unfortunate outcome of this belief is that maximizing live weight gain per hectare has become an identifiable goal — whereas maximum profit occurs at a stocking rate somewhere between that which maximizes gain per head and gain per hectare. Holmes (1988) notes that from a practical perspective this point may be ill defined — so that near maximum profitability may occur over a comfortably wide range of stocking rates.

Stocking rate is the single most potent factor which the manager can control to affect his animal production and pasture stability. Increasing stocking pressures, under any guise, is the antithesis of conservative rangeland management in Australia today (Burrows 1990b).

Conclusion

Management of our huge pasture resources in the future will be based on a better understanding of the 'tree-grass' balance and the manner in which this can be maintained; better appreciation of the effect of heavy use on pasture productivity and resilience; realization of the enormous potential to augment native pastures with introduced legumes; and, a better understanding of the ecological status of pasture systems which will allow management to take cognisance of the physiological needs of the plants on which animal production ultimately depends. In all situations the integrity of the underlying soil should never be put at risk.

Sustaining introduced pastures is mainly a question of economics — if the energy inputs (tractor, fertilizer, seed, sometimes irrigation) warrant it there is little reason to doubt that we can not maintain (or recycle) introduced pasture systems, even by dealing with acidification if it occurs. Unfortunately the enthusiasm which usually goes hand in hand with planting introduced species is rarely matched by plans to deal with their inevitable (?) rundown or changing management requirements. Greater responsibility needs to be taken in this area by both researchers and end users, if we are to avoid the rightful wrath of environmentalists.

Where we can no longer afford to use high energy inputs then it is clear that the ecological and physiological requirements of the sown species should match the niche available. The need to access the widest possible gene pool is readily apparent. Thus attempting to maintain successional or high N demanding species in a low N supply environment will result in ultimate disappointment.

In naturalized and native pastures more attention needs to be given to defining 'proper use' — what is the appropriate stocking rate and grazing pressure to maintain these pasture systems? Both plant and animal parameters may provide some guide, for example, in induced grasslands grazing pressure might be adjusted to ensure that average liveweight gains do not fall below 150 kg/hd/yr; for black spear grass pastures a target of 110 kg/hd/yr might be set. Plant parameters are more difficult to define. The questions that need to be asked include:

- Is it possible to identify indicator plants whose presence in our systems are symptomatic of overgrazing or underuse?
- What tree-grass ratio and structure is advisable?
- What is the desirable plant composition which satisfies the requirements of production?
- What minimum basal cover status ensures landscape stability?
- Can we employ photographic standards for pasture use as a guide to management? and
- Can pasture growth models and rainfall records be combined to make informed and prescriptive stocking rate decisions.

Australia's tropical pasture systems are an enormous resource, while the answers to these questions will generally be specific to each region and pasture type. But whether introduced, native or naturalized the pastures are mostly quite 'fragile' and easily converted to a less desirable state. Until their dynamics are fully understood and predictable, conservative use is the best approach to continued maintenance of these systems, and the livestock industries which are founded on them.

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