Sustaining productive pastures in the tropics
2. Managing woody vegetation in grazing lands

J.C. SCANLAN[1], B.J. WILSON[2] AND E.R. ANDERSON[3]
[1]*Department of Primary Industries, Charters Towers and* [3]*Rockhampton; and* [2]*Department of Lands, Charters Towers; Queensland, Australia.*

Abstract

There has been a lot of interest in northern Australia recently in terms of our woodland resources: we still have trees whereas widespread clearing of native vegetation has occurred in southern Australia and overseas.

The impact of native and exotic woody plants on understorey vegetation, cattle production and soils are discussed. The spread of introduced woody weeds is a major concern in many areas, with leguminous trees and shrubs being a serious threat to millions of hectares of natural grasslands.

More research is required into herbaceous responses to clearing woody plant populations, and the associated impacts on subsequent woody plant dynamics, landscape hydrology and wildlife populations. Coordination between government departments is required to develop appropriate clearing guidelines (for both native and introduced woody plants). More emphasis should be placed on cattle and land management following any woody plant removal. Lack of appropriate management is a major cause of degradation in cleared woodlands, and that is often attributed to the clearing itself.

Resumen

Ha habido recientemente un gran interés sobre los recursos forestales de la región norte de Australia: mientras que la expansión de la remoción de la vegetación nativa ha ocurrido en la región sur de Australia y en el extranjero, nosotros aún tenemos árboles

Se discute el impacto de las plantas leñosas nativas y exóticas sobre la vegetación baja, la producción del ganado y los suelos. La expansión de malezas leñosas introducidas es la mayor preocupación en muchas áreas, en las que las leguminosas arbóreas y arbustivas constituyen una seria amenaza a los millones de hectáreas de pasturas naturales.

Se requiere más investigación relacionada con las respuestas de las plantas herbáceas a la remoción de la población de plantas leñosas, y los impactos asociados con la subsecuente dinámica de las plantas leñosas, el panorama acuífero y la población de la vida silvestre. Se requiere una coordinación entre los departamentos del gobierno para poder desarrollar guías apropiadas de remoción (de las plantas leñosas nativas e introducidas). Se debiera dar más énfasis al manejo del ganado y la tierra después de cualquier remoción de plantas leñosas. La falta de un manejo apropiado es la causa mayor de la degradación forestal, la cual es frecuentemente atribuida a la remoción per se.

Correspondence: Dr J.C. Scanlan, QDPI, P.O. Box 183, Charters Towers, Qld 4820, Australia.

Paper presented at the Fourth Australian Conference on Tropical Pastures, held at Toowoomba, Queensland, in November 1990.

Introduction

Most woodlands and shrublands of northern Australia are used for production of beef and wool. The management applicable for this primary land use is quite different from that of other uses (*e.g.* tourism and timber). The main challenge is to use these resources for current economic benefit while not reducing future potential for other land uses.

In native eucalypt woodlands, trees compete strongly with grasses for moisture and probably nutrients (Walker *et al.* 1972, 1986; Scanlan and Burrows 1990). However, many of these woodlands are productive in their natural state and in these situations the most appropriate management of woody vegetation is to maintain the existing structure and density.

Impact of woody plants

The presence of a woody plant has many effects on the soil (Prinsley and Swift 1986) and the grass understorey. In some cases, the native grasses are replaced by introduced species (*e.g. Panicum maximum* beneath *Albizia lebbeck*, Lowry 1990; *Cenchrus ciliaris* beneath *Eucalyptus populnea*, Christie 1975). The most probable reason for the change in species composition is the altered nutrient status beneath tree canopies (*e.g.* Dowling *et al.* 1986; Figure 1). Increased nitrogen availability occurs in shaded microclimates (Wilson *et al.* 1986).

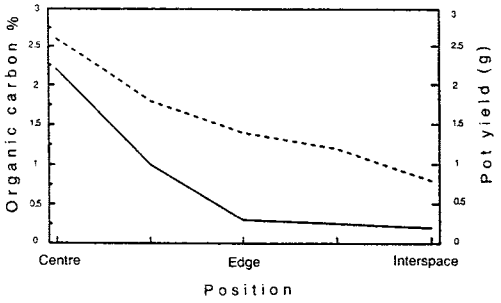

Figure 1. Organic carbon (....) and yield (—) of *Cenchrus ciliaris* grown in soil collected from a transect connecting the centre of a coalesced *Prosopis glandulosa* cluster to an associated interspace devoid of woody plants (from Scanlan 1988b).

Most trees have some "beneficial effect" on the soil beneath their canopy, however competition for water and nutrients often dominate this slight stimulation effect (Scanlan 1992). A greater understanding of the interaction of water and nutrients in relation to trees and grass growth is essential if the long term impacts of modifying woody vegetation structure are to be predicted.

Removal of competition from woody plants leads to an increase in pasture production, with the largest proportional increase being in denser woodlands on infertile soils (Scanlan and Burrows 1990). There will be some decline with time in the general production levels as the higher nutrient status under the tree canopies gradually declines to the level of the surrounding areas. These pastures are known to be stable over periods of 50-100 years, but whether they are stable over longer periods is not known.

The reduced pasture production due to competition from trees results in lowered potential stocking rates (Table 1). An associated effect is that an area with trees has wider fluctuations in pasture production compared with open areas. This leads to a greater potential for overgrazing in timbered areas, given a constant stocking rate (Table 1). Thus the management of timbered grazing lands is more difficult compared to naturally open or cleared lands.

Table 1. Comparative cattle production characteristics of a timbered paddock (*Eucalyptus crebra* with 6 m^2/ha of trees, on a duplex soil producing 1150 kg/ha in an average year) and a cleared paddock (on same soil type, producing 2500 kg/ha in an average year) receiving 600 mm average annual rainfall. Over a 15 year simulation period, 3 very poor, 3 poor, 3 average, 3 good and 3 very good seasons were randomly selected. Both paddocks are capable of carrying 100 head of adult cattle in an average year at 40% utilisation of yearly pasture production. Calculations made using GRASSMAN (Scanlan and McKeon 1990).

Performance criterion	Timbered (530 ha)	Cleared (270 ha)
Potential cattle number per paddock in poorest year (assuming 40% consumption of forage produced per year)	18	45
Potential cattle number per paddock in best year (assuming 40% consumption of forage produced per year)	203	142
Percentage of years that utilisation exceeded 60% at set stocking rate of 100 head per paddock *i.e.* pasture vulnerable to damage by overgrazing	45	27
Long term "safe" carrying capacity (defined here as constant number of cattle per paddock that gives <40% utilisation in > 70% of years)	50	82

Another major impact of woody plants is that they interfere with property management (*e.g.* mustering, stock access to water), particularly some of the introduced woody weeds. Poisonous plants (native and introduced) can cause serious stock losses under specific conditions.

Native woody species

In most cases, the management of woody vegetation tends to focus on reducing the density of the

naturally occurring plant populations. However, in some eucalypt areas, increases in populations of *Eucalyptus* spp. and *Acacia* spp. have been of major concern over the last 10-20 years. This appears to be related to the removal of fire from the system which has accompanied the use of supplements and *Bos indicus* cattle: both of these management strategies allow a greater proportion of the dry matter produced to be eaten. Also in the *Acacia aneura* communities, the spread and increase in density of *Eremophila, Cassia* and *Dodonaea* has become a major concern (Harrington *et al.* 1984). Despite the obvious loss of production from increased woody plant cover, control of woody weeds in semi-arid rangelands is often economically unattractive for the private landholder (MacLeod and Johnston 1990).

A degraded *Acacia aneura* landscape which has no useful shrubs and where the woody plants merely compete with the native grasses can be very similar in appearance to low shrublands of southern Australia. The major difference is that many of the chenopod shrubs in southern areas are edible and are an indication of good condition.

Woody plants are well suited to many parts of northern Australia, and one management option is to replace unwanted trees with useful ones. Some possible candidates are *Albizia*, *Leucaena*, *Gliricidia* and *Calliandra*. Even the shrubby stylos fit into this category as they behave more like shrubs than herbaceous plants, especially in their water use pattern.

Introduced woody species

There are a whole range of woody species that have been imported into northern Australia and are major or potentially major problems.

Calotropis procera is a typical example in many ways:

1) it has some benefit to stock, with high mineral content in young leaves;
2) it currently occupies a small total area, but is widespread and increasing in density;
3) it occupies the most productive parts of the landscape (frontage along the Gulf rivers); and
4) it can be chemically controlled but the cost of control in relation to the value of the land and the value of lost production is very high, and little control is practiced.

So it continues to spread and when or if it becomes a problem, the question will be asked "Why didn't someone do something about it when it was not a major problem?"

Cryptostegia grandiflora occupies about 700,000 ha in Queensland. Current control costs c. $6.5 million and it would require $700 million to treat all the area affected, and even then some follow-up action would be necessary (Chippendale 1990).

Mimosa pigra is spreading throughout many floodplain areas of the top end of the Northern Territory (Lonsdale *et al.* 1989). It would appear to be only a matter of time before it becomes established in Queensland, unless there is a continued and concerted effort on its containment.

Acacia nilotica was brought to Australia as a shade and fodder plant for the treeless mitchell grass plains. At low densities, *A. nilotica* does improve lambing performance. The main debate about usefulness revolves around a question of time frame — in the short term (< 10 years), a low population is beneficial, while in the long term (> 30 years), all indications are that an unproductive thornland is the only likely outcome (Carter *et al.* 1989).

Prosopis spp. is similar in appearance to *A. nilotica* and there are a number of species present in Western Australia (WA), the Northern Territory (NT), Queensland (Qld) and New South Wales (NSW). These appear to be slower growing than *A. nilotica* but are harder to kill with chemicals and appear to be adapted to a wider range of soils. There are millions of hectares in south-west USA and South America where *Prosopis* is a serious woody weed (Scifres 1980). *Prosopis* is present in the headwaters of rivers that flow into the Gulf of Carpentaria, and the inland drainage system. There appears to be no reason why the channel country will not be partially covered by *Prosopis* if current rates of spread and lack of control continue.

Other problem species include *Eriocereus martinii* and *Mimosa invisa* (both of which are under biological control), *Ziziphus mauritiana, Lantana camara, Parkinsonia aculeata* and *Jatropha gossypifolia*.

Many serious introduced weed species have some of the following characteristics:

1) thorny legumes;
2) heavy seed production with a high proportion of hard seed. (This makes control very difficult as there has to be a program to remove the mature plants as well as a continuing program to remove the new seedlings); and

3) seed pods attractive to animals (domestic and wild). Domestic animals spread seed within a paddock (increasing density), while floodwaters and wildlife are important in increasing the range (extent) of these species.

Control of unwanted woody plants

Determining appropriate methods for removing unwanted woody plants is a complex procedure as many factors will influence the "best" choice. Abiotic factors to be considered include climate (rainfall amount and distribution), soil (texture, depth and fertility) and the economic situation of the landholder (e.g. level of debt, degree of equity in property, cash flow). Characteristics of both the woody species and the herbaceous understorey species will influence the effectiveness of control methods. Some generalisations are given by Scanlan (1988a) and Burrows (1990).

Native species

Little clearing has occurred in northern grazing lands compared with that which has occurred in south-western WA, southern SA, south-eastern NSW and Victoria (AUSLIG 1990). In Queensland, some development has occurred along the coast and in the brigalow lands, but in NT and northern WA, tree clearing is not a common practice.

Pulling a heavy chain between two crawler tractors is a common means of removing unwanted timber for pasture development. Regrowth is almost inevitable, with some control being necessary to maintain pasture production. Soil applied herbicides (tebuthiuron and hexazinone) are being used for this purpose rather than aerial sprays, especially in regard to *Acacia harpophylla* control. The chemical is placed beneath the shrub canopy, rain dissolves the chemical which enters the soil and is absorbed by the root system.

Tebuthiuron (Graslan®) was a real advance in timber treatment as it enabled a wide range of species to be aerially treated and also allowed plants of different sizes in the one area to be treated effectively (compared with the shielding problems that were experienced with 2,4,5-T and other foliar sprays). The precision with which the chemical can be applied, the low toxicity to animals and low mobility in soil means that this method has many desirable features from an environmental view.

In communities with a lower tree density (primarily in eucalypt areas), the stem injection technique is widely used. Cuts are made into the sapwood of the tree trunk and a small amount of chemical placed in each cut. This is often very effective, unless there is an understorey of *Acacia* spp. or juvenile *Eucalyptus* spp. present as some follow-up control would then be necessary.

Fire is a very effective treatment for timber regrowth provided that spelling is practiced to allow fuel build-up and provided that regrowth is not too high. Many graziers judge that in the short-term they cannot afford to burn as they need to use the feed. The problem is that in the longer term they cannot afford not to burn (or do some other treatment) as the tree competition will eventually reduce pasture growth and carrying capacity.

Blade ploughs are very effective but expensive. A heavy blade is drawn at 20-25 cm below ground and severs all root systems. Very few plants can withstand this severe treatment (Scanlan and Anderson 1981) and these machines can be used in quite large and dense regrowth.

Sheep have been used in southern inland Queensland to kill unwanted woody regrowth. This method is effective, but it is a severe treatment for both sheep and pastures: almost all perennial grasses are lost in such treatments. Goats can be used in an integrated approach to woody weed control, although they are often ineffective unless special fencing and management is used (Harrington *et al.* 1984). At low plant densities and relatively high stocking rates, cattle can reduce the amount of woody vegetation in both native and sown pastures (Tothill 1971; McIvor personal communication).

Introduced species

Control of introduced woody weeds is often expensive, especially in extensive grazing areas. The one point to remember is that this control should be regarded as insurance — it protects larger areas, and so the cost per hectare treated is not a useful criterion for judging cost/benefit. Thus, labour intensive methods (*e.g.* basal bark spraying) can be justified.

Biological control is the most economically viable option for controlling large, dense populations of introduced woody weeds. Good biocontrol agents for *Eriocereus martinii* and *Mimosa invisa* have been released recently.

However, there is no guarantee of success with biological control, no matter how great or thorough the effort.

Fire, blade ploughing and grazing animals have a role in the control of exotic weeds, as for native species.

Adverse impacts of clearing native vegetation

One of the main constraints to development being carried out along proposed guidelines is that most development occurs on a paddock by paddock basis, and these paddocks were often laid out without considering vegetation differences. However with planning in the initial phase, a system which incorporates timber belts and wildlife corridors can be designed.

Sensible approaches to clearing include leaving strips or clumps on slopes (Burrows 1990) but there are still those who regard trees as enemies. Even where tree clumps have been left, these are often too small and the patch cannot survive, let alone be self-regenerating.

Salting is perhaps the most serious of all problems associated with inappropriate clearing (Hughes 1987). It is almost impossible to reverse without wholesale replanting of trees and associated physical inputs. We have to be very careful to ensure that in any clearing operation, there is no possibility of salting.

Erosion is generally assumed to be a consequence of tree removal, but there is often serious erosion in undisturbed woodland. It is the management of these areas that is the key to erosion control, and in particular the amount of pasture left by the grazing animals is critical (Gardener *et al.* 1988; Pressland *et al.* 1991). If about 40% of yearly production is eaten, this will leave sufficient for pasture to regenerate and enough for ground cover to maintain low levels of runoff and erosion.

Future Directions

We need a balance between agriculture, modified woodlands and natural areas, to achieve the goal of sustainable production. To achieve this, there needs to be a blend of more research, and changes in government policy and community attitudes.

Research

Given the relatively small input into woody weed management and the high priority placed on this by grazier groups, present efforts in this area should at least be maintained, if not increased.

1. There needs to be more information on responses to clearing, both in terms of long term productivity of pasture and in woody plant populations. In particular, the interaction between nutrients and water in relation to tree and grass growth in the long term needs to be assessed. Simulation models incorporating this information will enable more informed evaluation of woodland development alternatives and prevent the serious tree decline observed elsewhere.
2. Appropriate strategies must be developed for managing areas from which woody plants have been removed. These strategies will differ among communities and even among different landscape elements within the same geographic area.
3. There is a need for a better understanding of hydrology and salting. It should be possible for any grazier to know the impact of clearing on the hydrology of the wider catchment.
4. There is a real and immediate need to quantify the effects of clearing on wildlife and to develop a sound basis for recommendations on vegetation management for wildlife.
5. The replacement of unwanted trees with useful ones appears to be one way of developing a desirable woody-herbaceous balance in northern Australia.
6. Ecological studies of introduced woody weeds are necessary to guide government policy and landholder action. The potential area covered is needed to determine possible economic impact of weeds that are currently at low densities and/or of limited distribution.
7. An understanding of the basic population dynamics of woody weeds (native and introduced) is fundamental to any management programme.

Government Policy

1. There needs to be better coordination between government departments in all aspects of trees on farms. Guidelines for each agroecological zone should be available. **However, there should be no move to make statewide or nationwide rules on clearing or planting of trees.** With the variety of landscapes and vegetation communities represented in each state, the imposition of statewide guidelines would be inappropriate.
2. A classification of watercourses (flow rate, depth, permanency) should be developed along with appropriate timber retention guidelines for

each category. Clearing along watercourses is a contentious point between government and producers. Much of this stems from the fact that watercourses can refer to anything from the size of a table drain along a road to a major river system.

3. In some states, rental on leasehold land is based on potential carrying capacity, rather than current carrying capacity. Thus, there is a monetary incentive for clearing and a disincentive for conservation. This imbalance must be addressed.

4. Government decisions on legislative control of introduced woody species need to be ecologically-based, with achievable goals, and developed in association with all relevant government and non-government agencies.

Attitudes

1. Increased awareness of the potential of introduced woody plants to become weeds is needed, both at a general public and government agency level.

2. The term degradation should be qualified when used, specifically to refer to reduced "quality" of wildlife habitat, agronomic production or soil resource. This would reduce the problem of sweeping generalisations in our "ecologically-aware" society.

3. Greater emphasis should be placed on cattle and land management following development as the key to long-term stability. Too often the development *per se* is seen as the culprit e.g. the erroneous assertion by some that tree removal *necessarily* results in soil erosion.

4. A wider issue is "How do we balance the national good versus the individual good?". What is economically beneficial to an individual property owner may in fact be undesirable from a national point of view — e.g. clearing rainforest. This social question has many ecological consequences for the use of northern grazing lands.

References

AUSLIG (1990) *Atlas of Australian Resources: Vegetation.* (Australian Government Publishing Service: Canberra).

BURROWS, W.H. (1990) Prospects for increased production in the north-east Australian beef industry through pasture development and management. *Agricultural Science*, **3**, 19-24.

CARTER, J.O., BOLTON, M.P. and COWAN, D.C. (1989) Prickly acacia: save dollars by early control measures. *Queensland Agricultural Journal*, **115**, 121-126.

CHIPPENDALE, J.F. (1990) An economic evaluation of rubber vine in Queensland : Preliminary findings. *Proceedings of the Inaugural Queensland Noxious Weeds Workshop 1990.* (Weed Society of Queensland, Brisbane.)

CHRISTIE, E.K. (1975) A note on the significance of *Eucalyptus populnea* for buffel grass production in infertile semi-arid rangelands. *Tropical Grasslands*, **9**, 243-246.

DOWLING, A.J., WEBB, A.A. and SCANLAN, J.C. (1986) Surface soil chemical and physical properties in a brigalow-Dawson gum forest, central Queensland. *Australian Journal of Ecology*, **11**, 155-162.

GARDENER, C.J., MCIVOR, J.G. and WILLIAMS, J.C. (1988) Dry tropical rangelands: solving one problem and creating another. *Proceedings of the Ecological Society of Australia*, **16**, 279-286.

HARRINGTON, G.N., MILLS, D.M.D., PRESSLAND, A.J. and HODGKINSON, K.C. (1984) Semi-arid woodlands. In: Harrington, G.N., Wilson, A.D. and Young, M.D. (eds) *Management of Australia's Rangelands* pp. 189-206 (CSIRO: Melbourne)

HUGHES, K.K. (1987) Soil salinity and salting can be prevented. *Queensland Agricultural Journal*, **113**, 27-30.

LONSDALE, W.M., MILLER, I.L. and FORNO, I.W. (1989) The biology of Australian Weeds. 20. *Mimosa pigra* L. *Plant Protection Quarterly*, **4**, 119-131.

LOWRY, J.B. (1990) Agronomy and forage quality of *Albizia lebbeck* in the semi-arid tropics. *Tropical Grasslands*, **23**, 84-91.

MACLEOD, N.D. and JOHNSTON, B.G. (1990) An economic framework for the evaluation of rangeland restoration projects. *Australian Rangeland Journal*, **12**, 40-53.

PRESSLAND, A.J., SCANLAN, J.C. and MYLES, D.J. (1991) Ground flora composition influences rainfall-runoff and soil loss in semi-arid tropical rangelands of Australia. *International Rangeland Congress, Montpellier. April 1991.* (in press)

PRINSLEY, R.T. and SWIFT, M.J. (1986) *Amelioration of Soil by Trees.* (Commonwealth Science Council: London.)

SCANLAN, J.C. (1988a) *Managing tree and shrub populations.* In: Burrows, W.H., Scanlan, J.C. and Rutherford, M.T. (eds). *Native Pastures in Queensland: The resource and their management.* pp 95-111. Information Series QI87023. (Queensland Department of Primary Industries, Brisbane.)

SCANLAN, J.C. (1988b) *Spatial and temporal vegetation patterns in a subtropical Prosopis savanna woodland, Texas.* Ph. D. Dissertation, Texas A&M University.

SCANLAN, J.C. (1992) A model of woody-herbaceous biomass relationships in eucalypt and mesquite communities. *Journal of Range Management*, 45(1) (in press.)

SCANLAN, J.C. and ANDERSON, E.R. (1981) Use of the heavy duty blade plough for control of woody regrowth in Central Queensland. *Australian Weeds*, **1**, 10-12.

SCANLAN, J.C. and BURROWS, W.H. (1990) Woody overstorey impact on herbaceous understorey in *Eucalyptus* spp. communities in central Queensland. *Australian Journal of Ecology*, **15**, 191-197.

SCANLAN, J.C. and MCKEON, G.M. (1990) *GRASSMAN — A Computer Program for Managing Native Pastures in Eucalypt Woodland.* (Queensland Department of Primary Industries: Brisbane.)

SCIFRES, C.J. (1980) *Brush Management: Principles and practices for Texas and the southwest.* (Texas A&M University Press: College Station, Texas.)

TOTHILL, J.C. (1971) Grazing, burning and fertilising effects on the regrowth of some woody weed species in cleared open forest in south-east Queensland. *Tropical Grasslands*, **5**, 31-34.

WALKER, J., MOORE, R.M. and ROBERTSON, J.A. (1972) Herbage response to tree and shrub thinning in *Eucalyptus populnea* shrub woodlands. *Australian Journal of Agricultural Research*, **23**, 405-410.

WALKER, J., ROBERTSON, J.A., PENRIDGE, L.K. and SHARPE, P.J.H. (1986) Herbage response to tree thinning in a *Eucalyptus crebra* woodland. *Australian Journal of Ecology*, **11**, 135-140.

WILSON, J.R., CATCHPOOLE, V.R. and WEIER, K.L. (1986) Stimulation of growth and nitrogen uptake by shading a rundown green panic pasture on brigalow clay soil. *Tropical Grasslands*, **20**, 134-143.