# PROCEEDINGS OF THE AUSTRALIAN RANGELAND SOCIETY BIENNIAL CONFERENCE Official publication of The Australian Rangeland Society

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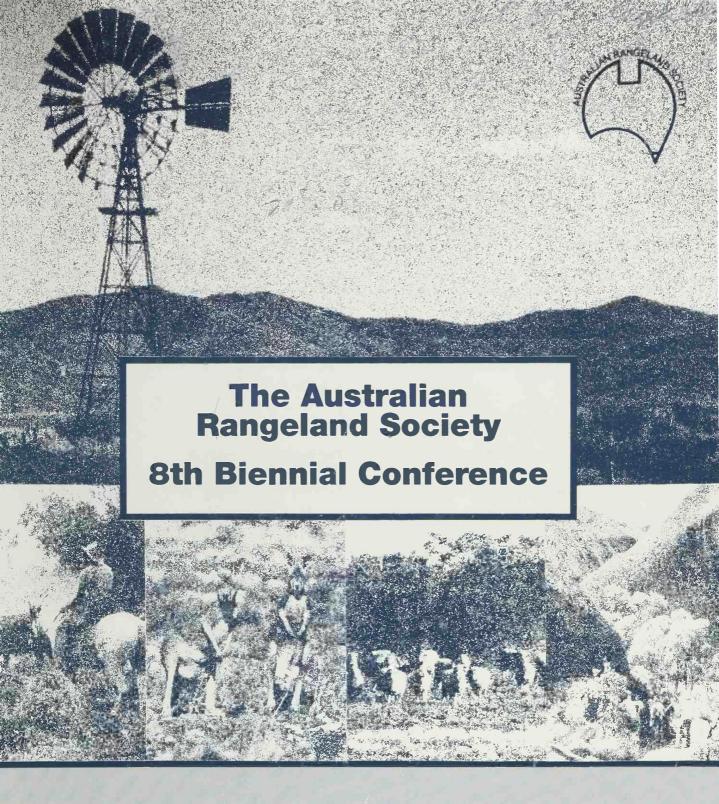
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## **PROGRAM**

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### MARKETING THE BIOTA AND LANDSCAPES OF WESTERN AUSTRALIA'S RANGELANDS

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<sup>1</sup> Director and <sup>2</sup> Science Adviser, Science and Information Division, Department of Conservation and Land Management, Australia II Drive, Crawley WA 6009

### **ABSTRACT**

Current usage of Western Australia's rangelands is very narrowly focused and has resulted in severe degradation in much of the pastoral zone. Historically, native vegetation in this zone has been valued only as a source of food for grazing animals. If, instead, the native species were valued for their commercial potential, they would be better conserved. Certain species of native plants in the pastoral zone could prove to be sources of novel chemicals marketable in the pharmaceutical industry. A bioprospecting vision needs to be developed for Australia's rangelands. The landscapes present in rangelands also have an intrinsic aesthetic value, which is marketable immediately through nature-based tourism.

The Department of Conservation and Land Management (CALM) is the agency in Western Australia responsible for integrating the conservation and utilization of the State's biota. As the State's nature conservation and land management agency, CALM has initiated an innovative scheme to add value to the biotic resource and to fund the conservation of the biodiversity that it manages. CALM has established bio-prospecting partnerships to screen the Western Australian flora for biologically active compounds and to establish the required pharmaceutical research and development infrastructure in Western Australia. CALM also works in partnership with the private sector to capitalize on the high, and escalating, demand for nature-based tourism. The community of Western Australia receives infrastructure funding and a share in royalties from any commercial products developed from these partnerships.

### INTRODUCTION

Western Australia has seen two major phases in wealth creation since settlement by Europeans. The first was the development of agricultural industries soon after 1829 (Burvill 1979). Growing wool under pastoral conditions became particularly important from the 1860s. The second phase was the development of mining industries from 1850, especially the development of the State's gold resources in the 1880s. This gave impetus to population growth and settlement of the State (Quartermaine and McGowan 1979).

The pastoral industry in Western Australia operates on 512 Crown leases over 95M ha, some 38% of the State (Government WA 1992). Leases in the Kimberley and Pilbara are used for cattle grazing, whereas those elsewhere are used mainly for sheep grazing. Forage comprises annual grasses and herbs and perennial grasses and shrubs.

Pastoralism in Western Australia reached its peak in the 1920s and early 1930s. This, in combination with drought in the late 1930s, resulted in extensive environmental degradation, including denudation of vegetation and erosion of soil. By 1940 in the Murchison-Meekatharra area, 75% of saltbush (*Atriplex* spp) and 25% of *Acacia* had been destroyed. Losses of up to 90% of vegetation were reported (Burnside 1979). The legacy of this is some 2.5M ha of severely degraded rangelands (Government WA 1992), proof of the concept that unless the natural environment pays its way, it is destined to be replaced by other, perhaps less appropriate, land uses.

In this paper we advocate two other wealth-generation means of considerable relevance to rangeland management.

### SUSTAINABLE CONSERVATION

The Gondwanic origin of the Australian continent and its long isolation have conferred a high degree of species endemism in its biota. Over geological and ecological time, species have had to cope with significant environmental uncertainty and stress: fire, drought, geomorphological change, predation,

herbivory, competition and disease. This has led to the evolution of many novelties. Only comparatively recently has it been realized that novelties extend from the familiar bizarre species (marsupials, eucalypts) down to the genetic level - the defences evolved against inimical factors are ultimately chemical in nature.

In the past few centuries, the search for cures to the hundreds of diseases afflicting humans has depended on knowledge acquired from indigenous people, serendipity, and medical research. Progress has been impressive, but slow. Now, with computerized and automated chemical screening procedures, it is possible to examine routinely hundreds of biological samples per day. Pharmaceutical companies are seeking to gather these samples for processing.

Unfortunately some collectors for pharmaceutical companies masquerade as *bona fide* scientists, obtain specimens at little cost, and onsell them. The method of extracting any promising biologically active natural products is then patented - any subsequent profits flow to the company and not to the community from which the species were collected.

Western Australia in December 1993 plugged this loophole by affirming its sovereign rights over its native flora through legislation. This will ensure that Western Australia receives a royalty from any commercial use of products derived from its flora. The other States and Territories and the Commonwealth Government are yet to take similar action.

Also in December 1993, CALM and the Australian pharmaceutical company AMRAD signed an agreement to develop an anti-HIV drug from an extract (Conocurvone) from a native plant species found in Western Australia. Although toxicological and chemical trials in the next 10 years could cost up to \$400M, the world market for an anti-AIDS drug is worth thousands of millions of dollars annually. If successfully developed, the royalty to the Western Australian community could be \$100M per year (Armstrong and Abbott in press). This royalty compares favourably with the annual royalty to WA from all mining of \$300M.

Only a small proportion of active ingredients lead to marketable pharmaceuticals. 'Hit' rates are between 1:6,000 and 1:10,000; one prominent company discovered only five marketable products in 25 years (Cunningham 1993).

What is the practical import of all this for the rangeland manager? The answer is that most medicines are still derived (extracted) from plants, rather than by synthesis in a laboratory. Thus, if as a result of biological screening any rangeland plant species proves to be a source of novel chemicals marketable in the pharmaceutical industry, then there is an opportunity for sustainable utilization of the plant species. Sustainable conservation, or bio-prospecting, therefore offers a possibility of diversification for the rangeland manager. Perhaps for the first time it provides a genuine incentive for the landholder to protect the native biota and ensure that introduced herbivores do not damage any newly discovered, economically highly valuable, resource.

Under this scenario, rangelands of Western Australia could supply raw material in partnership with CALM. CALM's role would be to ensure that the biological resource was harvested sustainably and that some of the financial return was used to support conservation of the resource. Suppose, for example, that a lead compound ("hit") was found in a native plant species on Crown land in the arid zone of Western Australia. In order to extract sufficient quantities of the compound for necessary testing, it would be desirable for CALM to attempt to access the resource as widely as possible. It could do this by entering a partnership with pastoralists whose leases have extensive populations of the plant species. These pastoralists would share in the financial return from sustainable utilization of the resource.

Martin (1993) criticized the Australian approach to conservation as emphasizing scientific research and population inventories **before** any sustainable use is permitted. He advocated an alternative, **adaptive management**, where the act of utilization forms the basis for the necessary research. Together with prudent setting of quotas and mor 'toring of what is taken, continual adjustments can be made to ensure that over-use of the resource cannot occur.

Probably the major example of an exploited native biological resource widespread in the rangelands of WA is Sandalwood (Santalum spicatum R.Br., A.DC). Unregulated exploitation took place between

1843 and 1929, when the Sandalwood Act was proclaimed. Sandalwood continues to fail to regenerate on rangelands because of browsing by introduced herbivores (Loneragan 1990).

### **NATURE-BASED TOURISM**

In 1992-3 some 400,000 international tourists (7% of all tourists) and 300,000 interstate tourists (6%) visited WA. They spent some \$600M (30% of all money spent by tourists) and \$500M (24%) respectively. Most visitors to WA came to experience a biota and landscape not available elsewhere. Many visitors from overseas are keen to seek out environments in which the density of humans is low by northern hemisphere standards. Spaciousness and remoteness can probably be best experienced in the pastoral region. Added to this are a night sky of stunning clarity, unpolluted air, a landscape rich in aboriginal myths, and an uniquely Australian biota (red kangaroos, euros, rock wallabies, dingoes, emus, cockatoos) observable during the day.

The hindrance to more rapid development of ecotourism is the vast distance between sightseeing opportunities - most visitors have neither the time nor confidence to drive the distances involved. In 1993, CALM therefore proposed the concept of an aerial tourist highway to co-ordinate existing infrastructure and attractions. What is missing is the packaging and marketing aspect - individual operators need to work co-operatively to produce a set of experiences other people are willing to buy. In the Kimberley, CALM is seeking value adding activities and working in partnership with tourist operators, Aboriginal groups, local government and pastoralists to promote nature-based tourism. The possible permutations of air and ground tours, cruises and homestead accommodation are limitless.

Ecotourism will involve a significant mindshift for many rangeland managers - economic liabilities such as pest populations of kangaroos, unproductive pastoral land and remoteness need to be thought of as economic assets. International visitors are unlikely to be interested in seeing cattle, sheep or degraded landscapes but are willing to spend money for those products or experiences that they need or want most.

We are not suggesting that pastoralists cease stocking cattle or sheep. Rather, we advocate that the most productive parts of the landscape are used as rangelands, and that stocking densities are reduced to prevent overgrazing, or if overgrazing has occurred to permit recovery of vegetation. The extensive provision of watering points in the pastoral region (in which water was originally in short supply) has benefited many species of native fauna. Large flocks of pigeons, finches and parrots at watering points are likely to be attractive to ecotourists.

It cannot be over-emphasized that ecotourism must be sustainably based, otherwise it is no improvement over traditional pastoral activities. It is in no one's interests when ecological assets are over-used and despoiled. There must be an ongoing and demonstrated commitment to visitor management and education.

### **CONCLUSIONS**

Rangeland managers now have the option to recognize several biological realities not known to their forebears:

- \* Pastoral holdings contain a considerable latent biological wealth. Any of the plant species present could harbour profitable, marketable chemicals, in which the pastoralist could share.
- \* In the more productive parts of the pastoral zone, it may be possible to add value to the indigenous flora by growing plantations of valuable species for seed or wood products.
- \* Ecotourism is a rapidly developing market pastoral Western Australia has many attractions for visitors.
- \* Native fauna offers exploitable products, though markets for them are currently either underdeveloped or undeveloped because of strict regulations forbidding exploitation.

Much of the pastoral zone is semi-arid and has low productivity. Therefore relatively minor infractions of ecological principles will result in major ecological impacts threatening the sustainability of rangelands. Allowing any degradation to occur is a significant opportunity cost - e.g. native plant species becoming locally extinct which may have harboured valuable therapeutic chemicals; native fauna becoming locally extinct represents forgone ecotourism values.

We believe that the native biota and relatively undisturbed landscapes of Western Australia can now provide an incentive for the rangeland manager to focus more broadly than on cattle and sheep. Our vision is that the generation of wealth from the State's biodiversity will be the third great phase in wealth generation in WA.

### **ACKNOWLEDGEMENTS**

We thank K. McNamara, S. Shea and T. Start for helpful comments on a draft.

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## DEVELOPMENT OF THE NATIONAL STRATEGY FOR RANGELAND MANAGEMENT AND ACTION PLAN

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The views expressed in this paper are not necessarily those held by all members of the National Rangeland Management Working Group.

### **ABSTRACT**

A National Strategy for Rangeland Management and Action Plan is needed to ensure that rangeland use is ecologically sustainable and biological diversity is preserved. The strategy is being developed by an ANZECC and ARMCANZ joint working group, which is committed to extensive public consultation, including the release of the Rangelands Issues Paper and draft strategy and action plan for public comment, and the holding of regional and capital city workshops. Issues range over environmental, economic, social, cultural and welfare areas. Commitment is needed to recognise the value of Australia's unique rangelands, the pressures facing both its natural resources and those who live and work there. All must share the responsibility for maintaining and enhancing its integrity.

### WHY A NATIONAL STRATEGY?

Rangelands are a very significant part of Australia: they encompass more than 70% of the country. Everyone has an interest in them; all of us have a responsibility to ensure that they are managed in an ecologically sustainable way, whether it be those whose work and homes in the rangelands are heavily reliant on available natural resources for their survival and prosperity, or those not living there who see it as part of their heritage, their outback.

The Prime Minister in his Environment Policy Statement of 9 March 1993 recognised that the rangelands are a neglected national asset, and that their continuing degradation is an urgent national problem requiring a national response. He committed the Commonwealth to work co-operatively with State and Territory governments, traditional owners, industry, the farming community and conservation groups to develop the strategy and action plan to reform land management in the arid and semi-arid regions (Keating 1993). A coordinated action plan is needed if we are to sustainably use the resources of the rangelands to develop industries and generate employment.

Australia's National Strategy for Ecologically Sustainable Development lays the foundation for all sectors of the Australian community to critically evaluate their use and enjoyment of Australia's natural resources.

What is Ecologically Sustainable Development (ESD)? ESD aims to meet the needs of Australians today, while conserving our ecosystems and the ecological processes on which life depends, for the benefit of future generations. It means developing ways of using those natural resources which form the basis of our economy in a way which maintains and, where possible, improves their range, variety and quality (Commonwealth of Australia, 1992).

### THE NATIONAL RANGELAND MANAGEMENT WORKING GROUP

The National Rangeland Management Working Group is a joint working group of the Australian and New Zealand Ministerial Councils for the environment, agriculture and resource management: i.e. the Australian and Yew Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ). Membership includes Commonwealth, and State and Territory government officers involved in land management as well as representatives of community interests, namely: the National Farmers' Federation represents pastoral interests, the Arid Lands Coalition represents environmental interests, and the Aboriginal and Torres Strait Islander Commission represents Aboriginal interests. Details of the working group's Terms of Reference, Principles and Membership are provided at Appendix 1.

Support for the development of the strategy is being provided through the Commonwealth government's "Rangelands Rescue Program" (\$0.5 million per year for each of 1993/94 and 1994/95) and through

various contributions by the States and Territories. It is intended that the strategy be presented to the Council of Australian Governments (COAG) for endorsement.

The need for a national rangeland strategy was identified at the 1992 bi-annual meeting of Arid Land Administrators. It was their subsequent representations through the South Australian agriculture and environment government agencies that resulted in the establishment of the joint ANZECC/ARMCANZ working group.

### **DEFINITION OF RANGELANDS**

The working group proposes that the boundary for the rangelands area be as used by the Bureau of Agricultural and Resource Economics (ABARE) for its pastoral zone (Figure 1). ABARE defines this area as that "excluding the wheat-sheep and high rainfall zones". The wheat-sheep zone is defined as including local government areas that carry a defined minimum area of wheat cropping (Australian Bureau of Agricultural and Resource Economics, 1993).

The ABARE boundary corresponds with the Australian Bureau of Statistics (ABS) Statistical Local Area (SLA) boundaries, which for the rangeland area generally correspond with local government boundaries. This would assist the contribution of current ABS data to the development of the strategy.

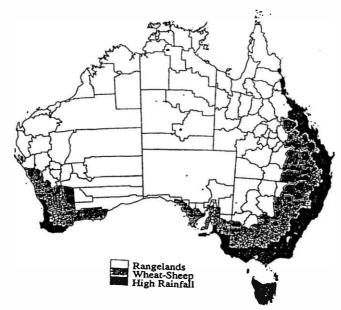


Figure 1. Rangelands area based on the pastoral boundary used by the Australian Bureau of Agricultural and Resource Economics.

In order to aid understanding of what the rangelands are, the working group has also developed a more descriptive definition for rangelands.

"Rangelands are areas defined by a combination of climate, vegetation and land use parameters. They are generally native grasslands, shrublands and woodlands which cover a large proportion of the arid and semi-arid regions and also include tropical savanna woodland, and the slopes and plains of northern NSW and southern Queensland. The majority of the Australian mainland, particularly the arid and semi-arid zones, is rangeland."

It will be necessary to use other boundaries derived from ecological and natural resources criteria in the development of the strategy's information base. For instance, the Interim Biogeographic Regionalisation of Australia (IBRA) framework being developed for use in the National Reserves System Cooperative Program (NRSCP) will provide a very useful tool for the investigation of our natural resource base (Thackway and Cresswell, 1994).

Notwithstanding the above, data availability is not ideal and it will be necessary for the working group to use whatever data formats are available.

### **PUBLIC CONSULTATION**

The primary mechanism for developing the strategy and action plan is by co-operation between the Commonwealth and the State and Territory governments, traditional owners, industry, the farming community and conservation groups. This involves substantial communication with the various non-government groups and is to be assisted by environmental information gathering.

The working group is going through three phases of public consultation. First, it released the Rangelands Issues Paper on 2 February 1994. The availability of the paper was advertised in the major newspapers in each State and Territory and the Weekend Australian, and referred to in a media release circulated to all country media outlets.

The paper was developed so as to assist identification of the issues considered important to the various interest groups and rangeland users. It did not pretend to cover all the issues. It was designed to act as a catalyst for preliminary discussion, while giving some direction as to known issues needing consideration. Over 4,000 copies of the paper have been distributed for public comment, both in response to public requests and via known mailing lists, such as that for the Australian Rangeland Society. As at 26 April, 135 submissions had been received. Only a few respondents have used the advertised toll-free telephone number which was made available for verbal submissions on the paper. Because of the time taken for knowledge of the strategy to find its way throughout the rangelands communities the time for public comment on the paper was extended to three months.

Second, the working group is at present undertaking a series of 27 public rangeland workshops that are enabling participants to contribute to the development of the strategy. These are being held in regional rangeland centres and capital cities. A national strategy and its action plan will only contribute to the responsible management of the rangelands if it has the support and ownership of most Australians, be they living and working in the rangelands or if their only contact with the rangelands is when they visit Uluru National Park. The workshops provide the primary opportunity for people and organisations to provide input into what the draft strategy and action plan should indicate.

Third, the working group will be seeking the endorsement of ANZECC and ARMCANZ for public release of the draft strategy and action plan in early 1995 to allow for several months of public comment. The mailing list developed for the distribution of the Rangelands Issues Paper will be used as the starting point for the distribution of the draft strategy and action plan.

A publicity program is being developed to increase community awareness of rangeland issues. The initial stages include use of regular media releases and brochure distribution. Advertising and the use of radio Community Service Announcements are being investigated, as is the use of a regular newsletter.

### SOME OF THE SIGNIFICANT ISSUES

Development of the strategy involves both urban and rural Australia. However it is not uncommon for concern to be expressed by rural Australia about the unwelcome involvement of urban Australia in the development of the strategy.

What are some of the essential questions?

First, it is essential that we know and understand the rangeland resource. What is its biological, geophysical and heritage diversity and values? How does it contribute to Australia's economic development? What are the threats to the resource and how can their impact be ameliorated or prevented? What state is our rangelands really in?

Second, it is essential that we know the people living and working in the rangelands. What are their aspirations? What are their perspectives on the state of the rangelands? What do they want for their children? What financial and social frameworks influence their decisions? How are their lives influenced by the availability, or lack thereof, of services normally available to the urban population? Third, it is essential for us to understand the affinity for the area of those who live there. In particular, we need to strive hard to understand the cultural, social and spiritual aspirations of the Aboriginal

communities, while not losing sight of their economic development needs, if they are to be given an effective opportunity to participate in the mainstream economy.

Fourth, people whose primary language is not English are a significant part of our society. How do we take their views into account? In fact how do we consult with them?

Fifth, what are the expectations of the wider community? How do people living in, say Melbourne, feel about their outback?

Sixth, what are the influences of government macro-economic, micro-economic and structural adjustment policies on the economic development of the rangelands?

Seventh, how do you assess the less tangible value of the rangelands' contribution to Australia's identity or to the country's defence.

Finally, what is the acceptable process needed to resolve the wide range of interests involved if decisions on appropriate ongoing and future management actions are to be made? How will this process incorporate social and political assessments?

### COMMONWEALTH EXPECTATIONS

What are the expectations of the Commonwealth?

Needed is the development of a workable Commonwealth/State agreement that ensures a coordinated approach to the reform of rangeland management. This will require a lot of work and goodwill. Irrespective of the extent of agreement between governments on the final strategy and action plan, probably the most important outcome will be the establishment in the action plan of a process for ongoing assessment and review of rangeland management.

It is essential that we do not end up with a strategy of motherhood statements which just re-iterates the obvious. We need the collective wisdom of many people and organisations to ensure a realistic and responsible action plan which will assist decision making by land managers, private and public.

The vision is for community recognition of the value of Australia's unique rangelands and of the pressures facing both its natural resources and those who live and work there. A commitment is needed by all to share the responsibility for maintaining and enhancing its integrity for future generations of Australians.

### **CONFERENCE OUTCOMES**

We look forward to the assistance that Conference participants and members of the Australian Rangeland Society can make to the development of the strategy and action plan, and would encourage you to do so.

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#### APPENDIX 1

### TERMS OF REFERENCE, PRINCIPLES AND MEMBERSHIP OF THE NATIONAL RANGELAND MANAGEMENT WORKING GROUP

### TERMS OF REFERENCE

Prepare a draft National Strategy for Rangeland Management and Action Plan for the sustainable use and conservation of those arid, semi-arid and tropical zones of Australia where livestock are grazed predominantly on native vegetation, in consultation with affected industries and communities, including appropriate Aboriginal groups.

#### The strategy will:

- examine the implications of existing and evolving strategies, policies and practices for sustainable rangelands use and management, including opportunities for alternative resource use;
- ensure links with other initiatives, strategies and policies in an integrated and coordinated way;
- consider roles and responsibilities of various levels of government and the community and opportunities for co-operation;
- identify economic, social and ecological issues requiring a national approach for their resolution;
- identify gaps in the current policy framework and propose action for addressing those gaps;
- report on the resources required for implementation of the plan of action; and
- consider the implications of emerging government policies in relation to native title rights.

### **PRINCIPLES**

- The rights of rangeland title holders and users must be respected.
- Stakeholders should be involved in the development and implementation of the strategy from the outset.
- The land user is primarily responsible for land management in accordance with land tenure conditions.
- Land management cannot be considered in isolation from groundwater management in the rangelands.
- Human intervention has long been a factor in the evolution of rangelands and will continue.
- Aboriginal cultural needs on rangelands require recognition.
- Flora/fauna conservation requirements extend across all rangelands regardless of tenure.
- High climatic variability and extremes are features of the rangelands.
- Multiple use options for rangelands exist in some areas, requiring appropriate management.
- Prevention of soil, water and vegetation degradation is more cost effective than resource rehabilitation.
- Agricultural use is to be ecologically sustainable.
- The range of present intergovernmental agreements and strategies should be recognised and built upon.

### **MEMBERSHIP**

Chair:	G Robertson (WADA)		
	ANZECC	ARMCANZ	
NSW	-	P Davey (CALM)	
NT	-	B Wood (CCNT)	
VIC	-	-	
QLD	P Sattler (DEH)	W Hoey (QDPI)	
WA	I Kealley (CALM)	-	
SA	L Yelland (DELM)	-	
ACT	-	-	
CSIRO	G Pickup (DWE)	W Winter (DTCAP)	
COMMONWEALTH	D King (DEST)	O Kingma (DPIE)	
NFF			P. Waudby
Arid Land Coalition			R. Ledgar
ATSIC			C. Hagan

Secretariat provided by the Department of Environment, Sport and Territories, GPO Box 787, Canberra, ACT 2601. (phone: 06-274 1892; fax: 06-274 1927)

# THE LIVE EXPORT CATTLE TRADE LONGER TERM IMPLICATIONS FOR THE NORTH QLD CATTLE INDUSTRY

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QDPI, 1 Townsville and 2 Mt. Isa

### **ABSTRACT**

Major increases in the export of north Qld cattle to Asia raise questions of how NQ cattle producers will or should respond to this expanding market.

Traditionally, the most profitable turnoff from most NQ herds has been the heavy bullock, though there has been some shift in favoured areas to supplying stores to southern fatteners.

If NQ cattle producers are to be induced to supply the live export market on a continuing basis, as distinct from using it as an opportunity market, premium prices and/or higher branding rates will be required.

This paper concentrates on the analytical approach required to predict producer response to changing prices and suggests what these responses might be.

### STRUCTURE OF THE NQ CATTLE INDUSTRY

Most of the northern cattle industry is based on the production of steers or bullocks bred, grown and fattened on the home property. Single station producers usually fatten on their best country. Pastoral companies with strings of properties tend to specialise in breeding on the poorer stations and fattening on the more favoured areas.

Breeding is therefore the core activity, with overall enterprise composition depending on the age to which steers are kept following weaning.

Fattening of bought steers is less common and is undertaken principally in good seasons on better classes of country such as the Mitchell grass downs.

### TRADITIONAL TURNOFF

Age of male turnoff is probably the most important herd structure decision which north Qld cattle producers make. For much of the area, production of bullocks for the US market has been the main enterprise. Areas of better country are able to produce cattle for the Japanese and Korean markets.

Carcase weights above 300 kg attract a premium. This weight typically is achieved in three to four and a half years, except on poorer land types where it may not be achievable at any reasonable age.

### **VARIATIONS**

There is always an element of store selling in northern turnoff despite bullock turnoff generally being preferred. There are several reasons why producers sell stores when bullocks are apparently more profitable.

Under drought conditions younger steers often are sold because they are the only saleable or moveable animals, and because producers sell down to a nucleus of breeders.

Capital shortage forces some producers to sell stores. A herd producing bullocks has more capital on the hoof than one producing weaners, since heavier steers and bullocks are worth more than cows and weaners. The truth of this becomes obvious when a producer attempts to shift from weaner to bullock turnoff. While the weaners are growing into bullocks the only income is from sale of less valuable surplus cows. Producers may be trapped in store production by their inability to forgo cash income while herd capital builds up.

Finally, there are those who opt for younger turnoff because the quality of their cattle and their breeder productivity enable a satisfactory income from store production.

### **DETERMINING BEST TURNOFF POLICY**

Turnoff policy may be viewed from two perspectives, static and dynamic. The conclusions which result may differ.

Analysis can be with one of the herd budgeting packages such as Breedcow and Dynama (Holmes 1993), supported by first principles.

Using a static analysis we compare turnoff ages and consequent herd structures, assuming the same stocking rate for each turnoff age. From this we determine that younger male turnoff means running more breeders, and we calculate the gross margin for each turnoff age. An extension of this is to calculate breakeven prices at which, for example, live export steer turnoff replaces bullock production. Decisions from such calculations should acknowledge the increased risk associated with younger turnoff. This is discussed in more detail in a later section.

A key element of static analysis is that stocking rate is the same for each option. Carrying the steers an extra year requires carrying less breeders to make room for one more year of steers. The criteria for carrying the steers one year longer will be that the profit from doing so exceeds the profit lost by reducing the number of breeders.

### BREEDER PROFITABILITY AS AN INFLUENCE ON MALE TURNOFF AGE

For clarity of analysis, it is convenient to view northern cattle operations as comprising two separate enterprises. The breeding enterprise produces the stores, and the growing enterprise turns them into bullocks.

Breeder profitability varies mainly with branding rates and the value of stores, while the profitability of growing depends on the cost of stores, growth rates, and price premiums for target weights.

With low branding rates, the greater the proportion of growing and fattening in the enterprise mix, the better the aggregate profit.

With branding rates of 75% or more, the gross margins from breeding and growing may be more nearly equal, so age of male turnoff then has less effect on overall profit.

"Best" age of turnoff is determined by the relative returns from breeding versus growing and fattening. Younger turnoff can become more profitable if branding rates improve through better husbandry, or store prices improve relative to bullock prices. Increased store prices, if bullock prices remain the same, will also erode the profitability of bullock turnoff both absolutely and relative to breeding.

### RESPONDING TO CHANGING SEASONS AND MARKETS

Static analysis is very useful for determining "policy", but less useful for determining how we should respond to varying seasons and markets.

Decisions in the real world centre on what to sell to satisfy this year's stocking limits and cash requirements. These decisions, as in static analysis, can be guided by the principle that we retain the animals with the greatest future profitability and sell those with the least.

It should be stressed that profitability includes increase or decrease in the value of animals over time. Thus heifers which are too young to produce calves but are increasing in value may still be more profitable than older cows which do have calves but which are dying and depreciating rapidly. In a dynamic sense, a high price today which may evaporate in the future would indicate low future profitability and would therefore suggest selling now.

In static analysis, the decision to hold a group of animals to an older age requires a corresponding reduction elsewhere in the herd. To be "profitable", the group must produce a profit at least equal to what the displaced animals could have produced.

Groups in contention should be ranked on future profit prospects, and sales drawn from the lower end of this hierarchy. Ranking in the first instance will be on gross margin per adult equivalent (GM/AE), preferably after interest.

In dynamic analysis the same rules apply except that there will be more sales in dry years and less in the good ones.

Alternately, sales might be driven by the need for cash flow rather than by stocking limitations. This requires new rules, since capital, not feed, is now the most limiting resource. The aim now must be to maximise cash flow per unit of profit lost. The new profit hierarchy is one based on gross margin per unit of cash (\$000) produced by the sale.

Year by year decisions are driven by current and expected future prices, not the long term averages used in static analyses. What is best to sell may vary from year to year.

### WHAT PREMIUMS ARE REQUIRED FOR LIVE EXPORT STEERS?

The following are liveweight estimates for a range of ages in three areas of north Qld.

	"Crocodile"	Georgetown	Cloncurry
Liveweight at 18 mths (kg)	230	245	280
Liveweight at 2.5 yrs	295	325	400
Liveweight at 3.5 yrs	385	430	520
Liveweight at 4.5 yrs	460	520	na
Liveweight at 5.5 yrs	530	na	na

Price for existing bullock turnoff at 500 kg LW plus is assumed to be \$1.25/kg LW. Live export is assumed at age 30 months for "Crocodile" and Georgetown, and 18 months for Cloncurry.

Prices required to make live export as profitable as bullock turnoff are shown below. Premiums on the \$1.25/kg bullock price are shown in brackets.

	"Crocodile" Price (Prem)	Georgetown Price (Prem)	Cloncurry Price (Prem)
Branding 50%	\$1.37 (\$0.12)	\$1.40 (\$0.15)	na na
Branding 60%	\$1.30 (\$0.05)	\$1.29 (\$0.04)	na na l
Branding 70%	na na	na na	\$1.51 (\$0.26)
Branding 80%	na na	na na	\$1.46 (\$0.21)

These figures bring out an interesting point, in that the premiums required for the "Crocodile" and Georgetown examples (steers aged 2.5 yrs versus bullocks aged 5.5 or 4.5 yrs) are much less than for the Cloncurry example (steers aged 1.5 yrs, bullocks aged 3.5 yrs). This serves to highlight the complexity of the issue, which depends on the interplay between breeding and growing enterprise profit.

Breakeven prices will of course change as the bullock price fluctuates, though the required premiums may be more stable.

### RISK ASPECTS OF YOUNGER TURNOFF

One of the consequences of a shift to store production is a larger breeder herd which makes the enterprise more susceptible to drought. To some extent this can be mitigated by better breeder management, however this requires a higher level of input such as supplements and management.

Another undesirable consequence of younger turnoff is a narrowing of market options. Fattening margins have historically been more stable than store production so, in giving up fattening, producers will expose themselves to greater market risk. The combination of widespread drought and a depressed market, as experienced in 1993, is most serious for store producers. The live export trade

was a saviour for many producers in 1993 though prices were still depressed by the overall market situation.

A bullock producer always has the option of selling stores or fats, and producers with better country may be able to supply a number of slaughter cattle markets.

As well as having reduced options, a store producer faces a serious cash flow shortage if wanting to return to older turnoff. An early benefit of the change to stores is the release of capital as steer sales double up and less valuable cows are retained in their place. If stores later become unprofitable, producers unable to fund reconversion to bullocks then may be caught in "the store trap".

### WHERE TO FROM HERE?

The live export steer trade has had a profound effect on the cattle industry of northern WA and the Northern Territory. The success of the trade there has to be judged against the background of limited markets for older animals.

The north Qld situation differs in that there is a well established pattern of bullock production based on export to USA, and to a much lesser extent Japan. In Qld there are also suggestions from southern fatteners that the north should become their store nursery, producing animals with a greater infusion of *Bos taurus* than at present.

Response to either store market requires a shift away from the current pattern of profitability. This can be achieved if branding rates improve and/or if store prices increase relative to bullock prices.

Response to the southern market requires a change in genotype to cattle with more *Bos taurus* content, whereas existing tick resistant genotypes are mostly suitable for the live export trade. If the live export market in the future takes animals with a lower *Bos indicus* content, then producers of such cattle will have both the live export and the southern store markets open to them.

Premiums for live export steers seem to be more readily forthcoming than premiums for fatteners. In NW Qld these premiums may improve if Karumba is developed as a live cattle export port.

If there is going to be a shift towards store production in north Qld, we believe that it will be for the live export trade rather than for the southern fatteners. In the first instance the shift could be driven by prices, but could later be reinforced by better breeding performances as producers pay more attention to breeder husbandry.

Producers most tempted to change will be those with better branding rates. For them, the profit gap between bullock and store production is already small, and the premiums for live export steers may be enough to close the gap.

Breeder performance in north Qld is steadily improving with the wider adoption of early weaning, better weaner care, and phosphorus supplementation. Improved breeder performance, combined with the live export premiums, could induce a widespread shift to live export steer turnoff.

Even without proven long term profitability, there will continue to be some producers for whom the live export trade is a convenient drought outlet when other markets are closed. For others who "should" be producing bullocks but who are caught in the store trap, the live export premiums have been, and will continue to be, a blessing.

Both drought and marketing risks appear to be greater for store production than for bullock turnoff. Thus it is not enough for store production to become as profitable as bullock turnoff. Stores must be more profitable than bullocks, and by a margin sufficient to compensate for the extra drought and marketing risks.

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## LIKELY SURVIVORS IN THE WOOL INDUSTRY IN THE AUSTRALIAN RANGELANDS

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### **ABSTRACT**

The battle for wool growers in the rangelands is far from over due to continuing low wool prices, the after-effects of drought (in NSW & QLD) and high interest rates (1989-92). Unfortunately there will be many casualties due to these events, lack of opportunity to diversify and far too many poor economies of size.

### INTRODUCTION

To set the stage some basic statistics are needed.

There are currently about 4000 pastoral enterprises occupying 3.7 million km² in Australia. These properties support about 6 million cattle and 19 million sheep (Cunningham & Wilcox 1993, Table 1). The sheep population is about 14% of the national flock. The rangelands support about 300,000 or 2% of Australia's people.

Income generated from pastoral activities in 1992-93 was \$830 million (\$300 m from sheep and wool) (Stafford Smith 1994). In comparison, tourism generates \$36 billion and mining \$10 billion Australian wide.

It should be remembered that this \$300 million was in a period of severe drought in the NSW & QLD rangelands and a very poor wool market nationally.

Table 1. Area of rangeland and numbers of cattle and sheep by State in 1992 (from Wilcox & Cunningham 1993).

	NSW	NT	QLD	SA	WA	Total
Area (km²)	309,272	76,077	1,251,867	417,919	965,558	3,705,390
Cattle ('000)	137	1,3334	3,785	157	643	6,056
Sheep ('000)	5,175	-	10,288	1,300	2,447	19,210
Sheep Property Units	1,350	-	2,000	180	280	3,810

### WHAT DOES IT COST TO RUN A SHEEP?

Many sheep owners are surprised to find that it costs \$25-30 per ewe all-up (including living and debt servicing) to run sheep. Table 2 illustrates actual costs of a NSW woolgrower in the 1992-93 financial year.

The "all-up cost" of \$25-\$30 per ewe is consistent across Merino breeding areas of Qld, WA, NSW and Vic, as indicated by various landholder surveys conducted by the Department of Conservation & Land Management NSW, NSW and WA Depts. of Agriculture, Qld DPI, Vic Dept. of Agriculture and various rural consultants. The level of debt, stocking rate, the family size and age etc. will cause minor variation. No information was found for SA surveys.

Table 2. Costs per ewe (1992-93) (Wynne 1993)

Cost Item	Amount (\$)	_
Accounting	0.43	
Shearing	4.34	(some family labour used)
Bank fees	0.25	-
Drenches etc.	0.87	
Woolpacks	. 0.22	
Fodder	1.30	
Insurance	1.08	
Interest	4.13	
Power	0.61	
Motor Vehicle	1.08	
Repairs & Maintenance	2.17	
Subscriptions etc.	0.09	
Sundry	0.11	
Phone	0.34	
Wages plus owners allowance	9.57	
Rams (replacements)	2.61	
-	30.94	per ewe per annum

NOTE: 1) Rents, rates (which vary enormously with location) and depreciation were not included.

2) 8000 dse operation running sheep plus cattle. Employed man runs property for aged owner.

### WHAT HAVE RANGELAND WOOLGROWERS BEEN RECEIVING FOR THEIR WOOL?

At present much of the rangeland wool is receiving \$1.75-2.25/kg nett greasy (i.e. the money received by the woolgrower from the woolbroker after all selling costs are deducted). In 1992-93, some growers didn't cover wool advances from their brokers when they netted between \$1.00-1.50/kg greasy. Rangeland economists feel \$2.50-2.75/kg nett for wool PLUS reasonable sheep sales are needed to break even. This would mean a ewe and her offspring need to produce \$20 worth of wool (nett) and up to \$10 worth of surplus sheep sales to break even.

Unfortunately the 3.75 million bales held in the Wool Stockpile are made up of broader wool types (22-26 micron) that are produced in the rangelands. This means the shorter term prospects for rangeland woolgrowers aren't bright.

# WHAT HAS BEEN THE EFFECT OF RECESSION AND DROUGHT ON WOOL GROWERS INCOME?

Table 3 illustrates how four landholders with varying Rental Carrying Capacities (RCC) in the Ivanhoe district of NSW have fared.

Table 3. Nett selling proceeds per hectare.

Year	A (RCC 1:3.48)	B (RCC 1:3.84)	C (RCC 1:3.97)	D (RCC 1:4.8)
87-88	\$10.33	<b>\$7.88</b>	\$8.20	\$7.80
88-89	\$12.53	\$10.88	\$10.20	\$8.39
89-90	\$14.78	\$9.44\$	11.03	\$8.78
90-91	\$7.37	\$6.68	\$5.94	\$8.98
91-92	\$6.54	\$4.85	\$6.31	\$6.25
92-93	\$6.55	\$5.81	\$3.70	· <u>-</u>
	Mainly sheep	All Sheep	Has increased cattle herd	Heavy sheep losses in 1992. Has kept income up due to cattle enterprise

Due to confidentiality, costs are not quoted. However, these operators have all made profits or brokeeven in 1991/92 and 1992/93. Unfortunately they are a small minority, as is confirmed by information available from banks and rural counsellors.

The following estimates from ABARE's Region III Pastoral Zone field surveys illustrate what has happened in the NSW Rangelands:

Table 4. Data from ABARE Region 111 field surveys.

Year	Total Cash Costs	Total Cash Receipts	Closing Debt	Cattle	Sheep	Wool (kg)	Property Area (Ha)
1989	\$225,489	\$310,490	\$178,111	170	8333	51,702	24,478
1990	\$186,633	\$226,390	\$126,523	190	6720	40,053	24,888
1991	\$137,572	\$168,565	\$156,193	146	5691	31,442	23,842
1992	\$121,086	\$144,911	\$230,896	149	4467	25,355	24,955

NOTE: This information is based on a 2-3% sample survey which, in 1990-91 and 1991-92, was biased on the Brewarrina shire which is generally not affected by woody weeds.

### **Debts**

NSW rural counsellors report an average debt of \$350,000-\$450,000 from their clients. Average debt of all landholders in the Western Division is unknown, but is thought to be in the \$200,000-\$250,000 range. ABARE quotes a debt of \$230,000 per property in 1992-93, but this is only a 2-3% sample. This figure equates with a debt of \$40 per sheep.

The average debt of 50 growers to one bank in NSW in 1993 was \$52 per sheep, with some owing over \$100 per sheep. A Queensland DPI survey (Newman 1993) showed that the level of debt had risen from \$23 to \$34 per sheep.

### **Land Values**

Poor wool prices, the effect of the wool stockpile, drought and high interest rates in the 1991-93 period have put considerable pressure on land values. Documented declines in land values of 40-50% are common, and declines of 75% in severe woody weed infested areas have been observed.

### **Economies of Size**

Analyses of property size show that many leases have insufficient carrying capacity to be viable in the long term, even at the highest standards of management. The majority of leases in the Western Division of NSW have a rental carrying capacity of less than 6,000 sheep (Table 5) while 32% of properties in the WA pastoral sheep area are rated at less than 4,000 sheep (WA Taskforce 1993).

Table 5. Distribution of property size in the NSW Western Division (from Hassall & Associates 1992).

Rental Carrying Capacity	ying Capacity Total No. of Properties	
2-3,000	171	13
3-4,000	404	30
4-5,000	327	25
5-6,000	173	13
6-7,000	98	7
7-9,000	79	6
9,000	79	6
TOTAL	1331	100

NOTE: Properties with a rental carrying capacity below 2,000 sheep were excluded.

Whilst economies of scale are important, many landholders have ways of increasing income by addressing problems that exist on their properties; e.g. control of total grazing pressure, preventing the spread of woody weeds, whole property planning and better financial management. Additional land is of little value if the owner is not in the correct mental, physical or financial position to operate it

Due to variables such as location, level of debt, living standards and education needs to be provided for, it is extremely difficult to suggest a minimum carrying capacity for long term viability.

A major joint property build-up and rehabilitation scheme that addresses these issues is before the NSW, Queensland and Federal governments at present. If funding is made available, this program will run to the year 2000 with the aim of tackling the socio-economic and ecological problems of the Queensland Mulga lands and NSW's Western Division.

### PROFILE OF A LIKELY SURVIVOR

The Australian Bankers Association (1988) lists 13 causes of financial crisis: only two are external to the farm and they are:

- a) Adverse changes in market prices (this would include interest rates).
- b) Adverse seasonal conditions.

These two causes are part of the reason why 40% of Western Division pastoralists are seeing rural counsellors in 1993. But the survivor is characterised by the fact that he has planned ahead and utilises the concept of "a complete management package" (see Figure 1) to minimise the effect of these problems. The main components of this package were identified by the authors of the Eco-Stock survey as being:

- a) Conservative stocking and control of excessive native and feral animals commonly known as Control of Total Grazing Pressure (TGP).
- b) Provision of reliable water.
- c) Tight financial management and good simple records.
- d) Being aware of range condition and able to interpret trends.
- e) Having access to fodder, cash and/or credit reserves for difficult times.

This operator, whilst being aware of the need to constrain costs, has focussed on methods of improving "the bottom line". That is, what effect landholders' actions will have on improving profit or, in very difficult periods, reducing losses. Interestingly John Crosby from the National Farmers Federation recently stated farmer organisations had been more worried about the effect of costs to farmers. He said it would have been more fruitful to address ways of increasing income to improve profit rather than just cutting costs.

To illustrate the financial effects of managing drought (Table 6), the actual financial figures of one of the co-operators from the Eco-Stock survey will be used to compare:

- 1) successful drought preparation and performance (called A) against
- 2) results from other survey participants who experienced heavy losses and low production (called B).

Each operator has a \$200,000 debt at the start of the drought and each runs a flock of 4500 joined ewes. Grazier A has a reasonable wool cut (6kg/head) and lambing rate (70%) with slightly higher than normal losses. Due to control of Total Grazing Pressure in a severe drought this producer hasn't suffered serious production losses. Future production is also unaffected by the need to buy stock or breed-up numbers. In the words of this producer "I aimed to hit the ground running once the drought broke". In actual fact this happened and supports the concept that a "complete management package" will return superior performance.

Grazier B lost 2250 joined ewes and 600 hogget ewes, and had a 30% lambing. The surviving ewes only cut 4 kg of wool per head. In 1993 \$45,000 were borrowed to purchase 2250 joined ewes at \$20 each.

Table 6. Profit and loss figures (\$) for Grazier A (bold) and B (italic) (from Wynne 1994).

_	1992		1993		1994		1995		1996	
sales	133,000	26,000	154,000	80,000	165,000	131,000	192,000	140,000	210,000	172,000
costs	105,000	90,000	110,000	110,000	115,000	115,000	120,000	120,000	125,000	125,000
margin	28,000	-64,000	44,000	-30,000	50,000	16,000	72,000	20,000	85,000	47,000
loan	200,000	200,000	196,000	288,000	175,520	402,960	146,582	435,315	92,172	467,553
interest	24,000	24,000	23,520	34,560	21,062	48,355	17,589	52,237	11,060	56,106
stock loan			 	45,000		50,400	i	56,448		63,221
st ln interest				5,400		6,048		6,773		7,586
profit	4,000	-88,000	20,480	-69,960	28,937	-32,355	54,410	-32,237	73,939	-9,106
loan status	196,000	288,000	175,520	402,960	146,582	435,315	92,172	467,553	18,232	476,659

Note: Living and taxation expenses NOT deducted.

Total debt for Grazier B: \$539,880 (i.e. stock loan & term loan)

The projected loan status of Grazier A in 1996 is \$18,232 compared to Grazier B of \$476,659. In addition B has a stock loan which has compounded to \$63,221 giving a total of \$539,880 in loans.

### WHAT DOES THE FUTURE HOLD FOR RANGELAND WOOLGROWERS?

For producer B, barring a miracle, there is none. The survivors will be likely to have the following characteristics:

- Family run enterprises (the margins are too slim for many corporate investors).
- \* Have some members of the family unit who have experience outside of grazing and are thus able to handle the concept of new and different ideas.
- \* Be capable of implementing a "complete management package" as a result of being actively involved in property planning and having had exposure to new technology.
- \* Have improved management and increased property size where economies of scale were previously inadequate. This will probably have been achieved with the assistance of future incentives provided by government.
- \* Will be Involved in alternative industries if resources and time permit; e.g. tourism, value-adding, bush tucker, cattle, grain (in suitable areas).
- \* Have utilised Government incentives to prepare for the self-help principle and may have used:
  - 1) IED's for protection against drought and recession.
  - 2) Interest subsidies to increase property size.
  - 3) Interest subsidies for capital works to repair or prevent land degradation, e.g. NSW Special Conservation Scheme.
  - 4) Property planning workshops etc.

Pastoralism is no longer a way of life, but a hard cold business that will need to provide a family with an adequate living standard, educate children and enable them to take over the family pastoral business in a better economic and ecological condition.

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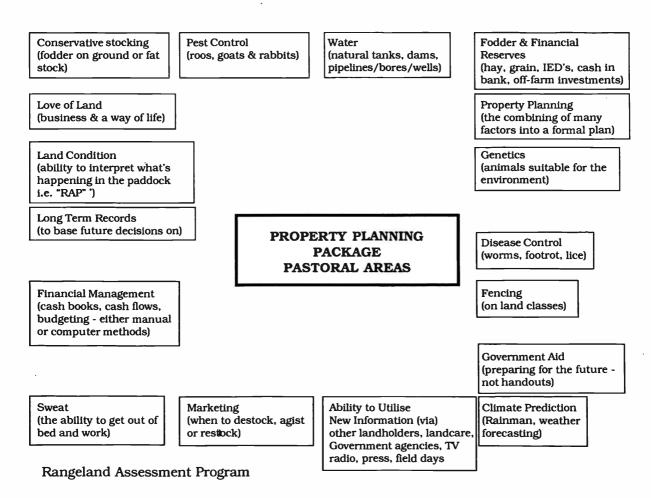


Figure 1. A Complete Management Package

### DROUGHT MANAGEMENT: A PERSONAL VIEW

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### INTRODUCTION

I have spent the bulk of my life being confused about drought. At least I have not been on my own, and I now realise that this confusion is reasonably widespread! Let me explain. Drought it would seem would be a pretty obvious thing. It conjures a picture of perishing livestock, shimmering heat, desperation and dust storms. That's fine - no one could confuse this picture with anything but drought. I had a feeling that drought was like a black (or perhaps red on account of the dust!) cloud that descended upon the land - something out of the ordinary and extreme, something dreaded that brought with it death and desperation; something that one could almost see coming, ravaging everything in its path and like a cancer eating away at our existence. Much of the information available for drought management was concerned with feeding starving stock; minimum water and feed requirements for various types of animals; and information on the various drought rebate schemes that have until recently been available.

Several things still nagged at me. Firstly, droughts never appeared as I imagined they should. One seemed to slip imperceptibly from a dry time into a drought. What's more, what was a drought for some people was just a dry time for others. When the drought was over, we never all seemed to come to the surface together. Some seemed to stay under for longer than others, even though we had all had the same amount of rain. As well, some seemed to take years to get over the effects while others did not. What was it about drought that made it so hard to define and so selective in its effects? Why was it that this wealth of information provided to me by the various agencies on drought management didn't appear to enhance my ability to manage drought in any long term way? Drought seemed to have two faces: one was the general conditions that it seemed to apply to the whole district, the other was the special circumstances in which I as an individual found myself.

Strangely, it was a fall from a horse that set me thinking, and provided some of the answers. It was some time ago when I was younger and more rash that I fell from a "green" horse doing a foolish thing. As a result I was laid up for some time waiting for the bones to heal. At this time I used to manage in a style where nothing on any of the properties happened without me. I did not realise that I was getting myself into a position where nothing "could" happen without me! When I was out of action things ground to a halt; and my management style had manifested itself into a serious problem. Calf marking and heifer selection ground to a halt. Things went into limbo. Following this I was determined never to let this situation happen again. Through planning and a change of management style the company can now run itself, though I like to think not as efficiently or effectively as if I were there (my staff would debate with me on this!). However, the important point is that through planning I have been able to reduce the detrimental effects of my absence.

I got to thinking about other influences that might threaten the enterprise. I realised that the way I had been thinking about drought was unlikely to provide a long term solution to managing drought in any effective way. What I was doing was thinking of management **of** drought, when what I needed to do was to think of management **for** drought. I knew that drought was inevitable; the question was not **if** drought was going to occur but **when**. Given that this question was impossible to answer with any certainty, the 'what' I needed to do was to develop a style of management that was going to place me in the best possible position when drought finally did occur.

There are two fundamental reasons for the need to plan to manage **for** drought and not **of** drought. The first is that by not recognising the need to manage for drought, there is a possibility of developing a type of management that is particularly vulnerable to the effects of drought. An example is people who appear to push their stations "too hard" and as a result appear to be the first to go into, and the last to come out of, drought. The other reason to manage for drought is that a failure to do so reduces the possible management alternatives when in drought.

#### INITIAL REFLECTIONS

I have called this "initial reflections" as I believe the first step is to reflect upon ourselves and the environment in which we live. There are two things that we have to come to terms with. The first is that we all have our own attitudes and values, perceptions and abilities. As well, we all want something slightly different from the land and from life, and what we want will perhaps change with time. The second thing is that we have to recognise the nature of the environment in the semi-arid areas and to accept that one of its characteristics is its inherent variability. The challenge is to construct a style of management that will accommodate, in the best way possible, both our needs as individuals and the variability of the environment.

Let me discuss the first point. My financial situation is such that I am not in a position to be a gambler. I require a minimum and preferably constant level of income, the higher the better. I recognise that through management I have an ability to go some way toward achieving this. However, I also recognise that my management ability is hindered by a lack of experience and information. I almost certainly make decisions too late, and I lack the experience that many of my neighbours have. On a more positive note, I am well placed to shift stock both on and off the property at short notice and with little loss of income because of the country I own elsewhere. Looking at my attitudes and values, I do not like to see animals perish, for whatever reason. Likewise there is a certain minimum level of condition that I do not like to see my pastures go below. Whether these levels are right or wrong is for the present unimportant. What is important is that they all define the management boundaries in which I operate. These factors (and there are many more than I have illustrated) define the context in which I make decisions. This context will necessarily be different for others - this is important as it means that there will be no drought management system that is suitable for all. How I manage for drought may or may not be suitable for someone else.

Having considered our ability to manage our attitudes and values, and the requirements that we need from the enterprise, the second step is to look at how these fit into the environmental context within which decisions are made.

The following figure is an example of the type of environmental information most commonly presented. This climatic data shows the mean average rainfall and temperature for a twelve month period.

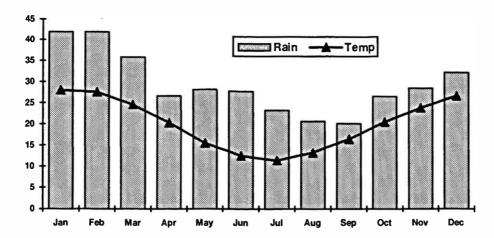


Figure 1. Mean monthly rainfall (mm) and temperature (°C) at Bourke NSW.

To my mind this sort of diagram is misleading in that there is no measure of variability, and as such, provides little useful information on which to base management planning decisions. The problem is the concept of "average". If we had to manage for "average" years, then this concept would be important, but as shown in the diagram below there is seldom such a thing as an "average" year.

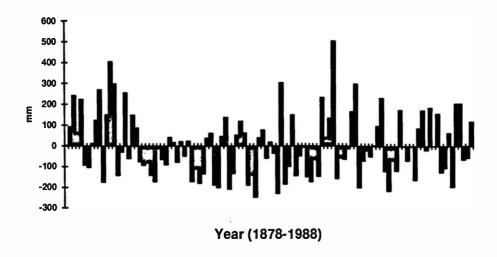


Figure 2. Bourke annual rainfalls showing departures from the long term average (349 mm) represented by the line at zero on the vertical axis.

The first thing to note from Figure 2 is that there is a wide variation around the average. Given this, the challenge is to manage for variability rather than the average. The second thing to notice is that in the last hundred years, there has not been a single "average" year. The notion of "average" is only a man-made construct which is misleading. We need to be thinking about the "most common" level of rainfall, and even with that we need to have some idea of the variability. One way is to look at rainfall deciles (shown in Figure 3), and these provide, within ranges of 10%, the probability of receiving more or less than a given amount of rain. For example in February, in 7 years out of 10 we can expect to receive less than 52 mm, or in 3 years out of 10 less than 10 mm. By comparison in September less than 38 mm can be expected in 7 of the 10 years and less than 5 mm in 3 years out of 10. Thus rain in February is usually greater but more variable than in September. This sort of information is important in making decisions, because even though the month may have a high average rainfall, the variability may be great (i.e. unreliable) and this concept gives some idea of the likely variability.

To develop long term management policies I need to know more than what the expected amount of rain for any given period is; I need to know the probability of a range of values. In other words, how certain can I be of getting a given amount of rain?

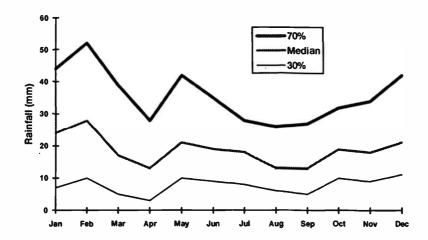


Figure 3. Monthly rainfall deciles at Bourke (based on the period 1871-1992).

There is one other point that needs to be made. Rainfall amount and variability must be considered in conjunction with other factors. For example, when are we most likely to receive "effective" rainfall? In my case, winter rain provides me with soft feed such as forbs and medics that do not carry over into the hotter months of the year. The more beneficial rain in summer grows grasses etc. which provide dry standing feed for months to come, but I have a lower probability of receiving effective rainfall in these times. Winter rains do not guarantee feed into the summer, whereas the reverse is true.

Rainfall figures can be roughly equated with the amount of available feed for any given year. Then, for a given rate of stocking (and thus feed demand), it is possible using Figure 2 to see for the last hundred years how many of these years would have produced a surplus of feed over and above the requirements of this rate of stocking, and in how many years feed supply would have been deficient.

### OPPORTUNISTIC AND CONSERVATIVE STOCKING

Opportunistic stocking refers to a level of stocking that attempts to utilise the available feed supply. Thus in good years stocking rates are increased to use increased feed supply, and in bad years they are reduced. Conservative stocking refers to a level of stocking at which feed demand is less than or equal to feed supply in more years than not. Referring back to the previous figures, a conservative level of stocking therefore fixes feed demand below or equal to that produced in the most common rainfall year. Opportunistic stocking will attempt to constantly balance feed supply and demand.

In practical terms the level of stocking is often a mix of these two extremes. The extent of that mix will depend on the requirements and abilities of the particular individual. It is important to recognise where the particular operation sits on this simplistic scale, to feel comfortable with it, and to know that it is possible to maintain this position. As well, one must appreciate that the two extremes have different requirements, and produce different results. Opportunistic stocking for example requires high mobility of stock, precise timing, and exact calculations of the requirements and supply of feed. It requires some estimation of future seasonal conditions (stock cannot be moved incrementally), and has high penalties if the estimation is wrong. If one is forced to sell these stock, such a sale could be at the bottom of the market and subsequent purchases at the top. Income will be more variable, though in some cases potentially higher. On the positive side, there is a potential to run a higher number of stock, and through that, the potential to capture the rewards of good seasons.

Conservative stocking on the other hand produces a more steady but lesser stream of income. There is less risk involved, and a lower level of management intensity is needed. In other words, there is more margin for error, and the whole system is potentially more forgiving. It is possible to set a hypothetical level of stocking and referring to the previous figure roughly calculate the number of years in the last hundred in which feed supply would not match demand. It is not strictly accurate, but it does act as a good rule of thumb to indicate some 'relative' position in stocking rate.

Why is all this important? Perhaps the main reason is that the level of stocking that one feels comfortable with will demand different requirements and skills, and produce different results. It is important to match the results with the requirements, both personal and economic, and to ensure that it is possible to achieve what one is setting out to do. It is important to recognise that we, as managers, have our personal limitations. Some of us have ability in certain areas while others will have ability in other areas. Some of us are better stockmen than others, but these same people may not necessarily be the best judges of feed supply, or alternatively, have the ability to make decisions and carry them out. Identifying my weaknesses is very much a crucial step in the process of strategic planning for me. For example, I am slow to make responses, and so a system that requires prompt and timely action (such as an enterprise that requires constantly matching feed and stock numbers for its success) is unsuitable for me.

Certain enterprises will define the management style. For example, it would be difficult to see how a cow/calf operation could be run in a fully opportunistic manner. Likewise, conservatively running an enterprise with only wethers would appear to be under-utilising potential. The whole thing is very much a matter of horses for courses. However, it is especially important to begin at this point, and to look at the requirements of the enterprise (i.e. financial, way of life, job satisfaction) and consider the strengths, weaknesses, threats and opportunities of any particular mix of conservative/opportunistic stocking.

### DROUGHT MANAGEMENT ON A PERSONAL LEVEL

Having progressed through the discussion above, the alert reader will realise that what I am about to say relates to my own conditions, and is not a general rule. What is right for me will not necessarily be right for someone else. However, I would venture to say that the process that I have been through is probably applicable to all, and indeed is a vital and indispensable step in drought management. Before I start there is one distinction that I wish to emphasise - that between strategic and operational decisions in the management of drought.

### Strategic and Operational Decisions

I see strategic decisions as being about the management of long term challenges which necessarily includes seasonal variability. Operational decisions are those that one makes in the midst of any particular situation and are more day-to-day or week-to-week decisions. These will include such things as forced selling, feeding or agistment. I see strategic decisions as being by far the most important; and depending on what strategic decisions are made, the range of operational decisions available in any particular instance could well be reduced.

The following figure represents diagrammatically the importance of strategic decision making. The horizontal axis represents time, with the vertical line E indicating the approximate start of a hypothetical exceptional season. The left hand vertical axis represents the number of operational decision choices available for management at the start of the exceptional seasons.

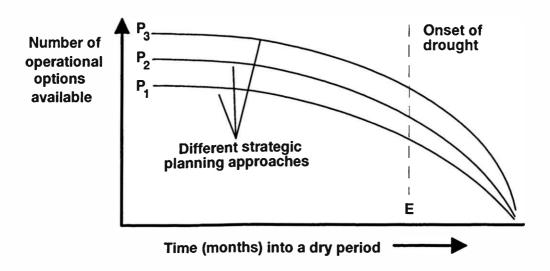


Figure 4. The relationship between strategic (long term) and operational (short term) decisions.

It can be demonstrated that if undertaken early enough, strategic decision making will significantly increase the management alternatives available when exceptional seasons are experienced, as in line P1. Alternatively, if few strategic decisions are made, or they are made too late, then when exceptional seasons occur there is only a small choice of management decisions available. In other words, our fate has been pre-determined and there are few moves that can be made to alter it.

With more comprehensive strategic planning, it is possible to increase the total range of alternatives available for management, and thus shift the curve upward to say P3.

I see drought management as being about strategic decision making. For too long, we have fallen into the trap of thinking that operational and strategic decisions were interchangeable. I am not going to discuss operational decisions, because they are very specific to the individual and the situation, and in many ways will have been pre-determined by what strategic decisions have been made.

### Management for Drought at Wapweelah

Wapweelah is approximately 150km north west of Bourke and is 84,000 acres in area. Rainfall is 250mm p.a. and variable. Rainfall can come at any time, though historically monthly rainfall is lowest in spring and least certain then. In January, February and March there is a 90% chance of having less than 100mm of rain in each month. For most other months, there is a 90% chance of having less than 50-60mm in the month. Though some people run cattle, only sheep are run at Wapweelah, with an "approximate" carrying capacity of one sheep to 10 acres. Wapweelah is run in conjunction with three properties in the higher rainfall tablelands area of NSW.

### (a) Philosophical position

There are several personal philosophical points that need to be made. Not all will agree with them - and for valid reasons. For me, they are incorporated within my system of beliefs:

- 1. I will always join, no matter what the season.
- 2. The time to make moves is when stock are fit and well. Leaving them until they are in drought condition is not satisfactory.
- 3. Because of my inability to control total grazing pressure, especially in times of drought, locking up paddocks is not an alternative.
- 4. The costs of acting too soon are small compared with the costs of acting too late.
- 5. Letting stock perish is not an option.
- 6. Cutting scrub is not an option (both from an environmental and economic perspective).

### (b) Property management

A deliberate attempt has been made to get the full potential from the property. Paddocks have been fenced smaller for more effective grazing. Water has been supplied to areas where it was non existent or which were ineffectively watered. There are plans for more yards and facilities in other parts of the property to maintain stock dispersion. The underlying aim is to get the most out of what feed there is, without causing damage.

Another consideration is to establish a regular monitoring program of feed supply and potential demand. There are certain times of the year when it is opportune to make assessments about the future. Not only should these coincide with points of seasonal significance, they should also coincide with property management activities. If these do not coincide, management activities should be changed to fit in with points of seasonal significance. For example, shearing is timed so it coincides with the end of summer and the beginning of winter. I know at that time how much carry-over feed is left at the end of summer, and at this time I know exact stock numbers. So it is an ideal time to make alterations. The ewes start to lamb in a couple of months and so can still be moved, and all other sheep are off-shears, and so can be moved at minimal cost. Weaners can be sold as well if necessary. Crutching is also timed to fit in with the most likely time for summer rain. So if there has been little rain sheep can be moved without extra work. Crutching and shearing then are planned to occur at times when reasonable decisions can be made about the future, based on expectations about the future supply and demand for feed. As the sheep are mustered anyway there is no double handling of stock, and therefore reduced costs.

Therefore property management considerations are:

- 1. fencing into land classes (or areas of varying fragility) and manageable areas
- 2. provision of strategically placed waters
- 3. provision of facilities (i.e. yards) to minimise stock handling
- 4. structure major activities around strategically important times
- 5. establish bi-annual or tri-annual review points to assess feed supply/demand.

### (c) Stock Management

Stock are managed in such a way as to make it possible to off-load stock at almost any time with the minimum of fuss. They are kept in groups of the same age or sex. As well, there is a deliberate move to keep a percentage of the flock in such a state as to make it possible to sell these without affecting the productive potential of the flock. The young breeders are considered the most important sheep in the hierarchy, and at the bottom are the wethers. These wethers are considered expendable, and will only be run provided the season is good enough. Should there be a question about feed, these sheep are sold, and in this way the productive potential is maintained. All stock are thus ranked in a hierarchy of value, and run in these groups so as to facilitate quick and easy off-loading should that be necessary.

Stocking rates are lower than many in the district, and the condition of the sheep is not considered a determinant of the rate of stocking. Likewise, the sale of sheep is not determined by their condition, but rather by the condition of the pasture.

Stock management considerations are therefore:

- 1. establish a hierarchy of value of stock
- 2. run stock in mobs of similar value
- 3. always be prepared to sacrifice one class of stock to maintain productive potential
- 4. pasture condition indicates the need for change long before the condition of stock
- 5. recognise that there are certain critical times, like lambing, when stock cannot be moved, and accommodate this. As well, it costs about 30% more to move a sheep before it is shorn rather than after.

### CONCLUSION

All of us will manage for drought in different ways. These ways will depend upon us as managers, our beliefs and values, and the physical and financial position in which we are placed. However, there will be some features common to all who manage drought with any degree of success. The first is that they will rely very much on strategic, rather than operational, decisions. Their management systems and patterns will have been developed long before drought is experienced. They will therefore have a wider choice of operational decisions available when drought does finally come.

Associated with this is the fact that successful managers will be pro-active rather than reactive in terms of their management. They will not have waited for the drought to occur before they decide what to do about it. When the drought does come, as it surely will, they will have organised themselves so that they are in the most advantageous position to handle it.

Those who manage drought so as to minimise its effects will in effect be managing for variability. By doing this, they are also potentially in a better situation to maximise the benefits of the good seasons. In the end, this will be what management in a variable climate is all about: minimise the losses from adverse seasons and maximise the benefits of good ones.

Finally, I find that by having a management strategy in place that accommodates both good seasons and bad, a lot of the stress is removed. When dry times come, what has to be done has been worked out already in general terms. I know when I am going to do something, and more or less what I am going to do. There is not the stress of trying to formulate a plan of action while under fire, as it were. The reduction in stress is a very real benefit for me, and I certainly can recommend that others should consider the benefits.

You may well ask how has the rest worked at-Wapweelah? Well, in the last four years (three of which have been continuous drought), wool cut per head has varied by 26%. The number of stock run has varied by 57%. Lambing has been 60% and above - I have some challenges here like pigs to overcome. Losses due to the drought have been minimal. When average losses from the last drought in the district have been reported to be around 30% in some areas, at Wapweelah they have remained at 4-5%. Where most people are purchasing sheep to re-stock, there has been no need to do so, and I will soon be selling surplus stock.

### **ACKNOWLEDGEMENTS**

I would like to acknowledge the generous assistance and advice that various people have given me in the preparation of this article and talk. Mark Stafford Smith provided particular support in refining my philosophies on drought management, providing comment on an earlier draft and assisting with the slides for my talk.

#### THE IMPACT OF TAXATION IN SOLVING LAND MANAGEMENT PROBLEMS

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**Note:** The authors are employed by NSW Agriculture in the Economic Services Unit. The views expressed in this paper are those of the authors, rather than those of NSW Agriculture or the NSW Government.

#### **ABSTRACT**

A recommendation of the National Strategy for Ecologically Sustainable Development is that governments ensure taxation regimes foster sound environmental practices. This requires greater consideration of the extent to which taxation concessions reduce the divergence between the private and social costs of resource use.

It is in this context that elements of taxation policy, including income averaging, income equalisation deposits and farm management bonds, sections 75B/D, livestock valuation provisions and the treatment of losses, are briefly discussed.

It is concluded that taxation concessions are likely to be ineffective in addressing social concerns regarding environmental values, and more generally, that sustainable resource use in the rangelands will require unprecedented clarity in objective setting by governments.

#### INTRODUCTION

Audience expectation of a presentation titled "The Impact of Taxation in Solving Land Management Problems" is likely to be identification of those provisions within the Income Tax Assessment Act (ITAA) that encourage landholders to undertake 'land care' measures.

This information however is widely available, and maximising landholder returns through the creative use of concessional taxation provisions should remain the domain of the accounting profession. Land administrators, researchers and economists should only be interested in these matters insofar as they impact on the achievement of more socially desirable resource use outcomes. In subsequent sections of the paper, the following points are made:

- \* the need to adopt a 'social perspective' with respect to role of taxation in influencing land management;
- \* that taxation policy is a poor means of targeting environmental concerns and taxation concessions are inconsistent with sustainable resource use; and
- \* the need for government to clearly define objectives underpinning policy intervention in the rangelands.

#### TAXATION POLICY AND SOCIAL CONSIDERATIONS

Land administrators, researchers and anyone working with industry run the risk of being 'captured' by industry and providing unquestioned support for measures that increase private returns, such as taxation concessions. Adopting a 'social' perspective is more difficult, requiring a level of objectivity that may alienate oneself from constituents who fund research salaries and provide political support.

It is interesting to consider the extent to which this trade-off between 'private' and 'social' concerns, or alternatively, between 'equity' and 'efficiency', has been a root cause of rangeland degradation and the extent to which it will continue to maintain the status quo in rangeland management for the foreseeable future.

Markets fail to provide socially desirable outcomes for various reasons including information deficiencies and costs imposed on third parties from market transactions (externalities). In the

rangelands, resource management problems relate more significantly to externalities, such as biodiversity loss, and the difficulties of internalising these costs.

While information provision may result in outcomes that are 'directionally' correct in terms of social preferences, externalities arising from resource use are the 'wedge' that make it impossible for information provision alone to generate socially desirable outcomes.

The key issue in relation to taxation and land management in the rangelands is, therefore, the extent to which taxation concessions reduce the divergence between private and social costs of resource use. As with any subsidy, the likelihood is that they will widen the gap, rather than reduce it.

#### TAXATION AS A LAND MANAGEMENT POLICY

Debate on taxation policy as a means of providing incentives for improved resource management has received considerable attention. Broad understandings that have emerged from this debate include the following:

- \* The use of an annual tax on nominal income promotes consumption over savings and investment, favours short term investments over long term investments and debt over equity finance. The increased financial risk associated with debt finance reduces the capacity of pastoralists to survive industry downturns, resulting in production strategies that exploit land and water resources.
- \* Taxation concessions are a 'second best' policy aimed at symptoms rather than causes, thus promoting activities that may be socially undesirable. In effect, society is rewarding, rather than penalising, undesirable practices.
- \* There is a poor relationship between the environmental values society wishes to preserve and the benefits that accrue to graziers who use taxation concessions to maximise personal income, rather than to address social concerns.
- \* Taxation concessions, as presently structured, only provide an incentive for capital works in areas and farming systems that are privately profitable. Where remedial work is required in low profitability areas such as the rangelands, and where the appropriate response is changed management practices, taxation concessions will distort management activity.
- \* Taxation concessions such as sections 75B/D provide benefits to high income producers on the highest marginal tax rates and provide no immediate benefit to graziers who make a loss, have carried forward losses or have an income below the tax-free threshold. To the extent that land degradation is more likely to be associated with low income producers, the approach is ineffective in targeting the problem.
- \* Taxation concessions (subsidies) break the fundamental rule of sustainable agriculture, requiring resources to be priced at their marginal opportunity cost to society. Apart from the fact that 'exchange' values are likely to underestimate the true cost of resource use, further production subsidisation through taxation concessions will certainly lead to inefficient resource use. For example:
  - subsidising watering points (section 75B) in the rangelands is likely to encourage overgrazing and discourage strategic stocking practices.
  - by reducing the cost of repairing land degradation (section 75D) further degradation will be encouraged. Of particular relevance to the rangelands is the extent to which it encourages capital intensive remedial measures in preference to non-subsidised measures, such as conservative stocking.

Section 75B: Provides a 3 year concession for specified capital expenditures relating to the conservation and conveyance of water.

Section 75D: Full deduction for specific capital expenditures relating to the prevention or control of land degradation.

Taxation concessions represent a regulatory or a 'command-and-control' approach to resource conservation. To be effective, such measures must draw on clear government objectives and accurate information about the functional relationship between polluter actions and the costs imposed on society.

The objectives of sections 75B/D, for example, are unclear. If an objective is to target privately

profitable remedial works in the hope this will be consistent with desirable social outcomes, then the inability of taxation concessions to address the range of degradation problems, regardless of income level, makes them ineffective. If on the other hand, the objective relates to income redistribution, then the bulk of benefits being received by high income producers makes them regressive.

In terms of information, our understanding of cause and effect relationships in the rangelands is limited at the operational level and is therefore probably insufficient to enable improved targeting of subsidy measures. This highlights the failings of 'blunt instruments' such as taxation policy in targeting environmental problems.

Despite the obvious inefficiencies of regulatory approaches, however, there has been little progress in moving toward market-based solutions due to difficulties of establishing rights-based systems and, perhaps more fundamentally, identifying those environmental values to which rights must be attached.

A useful 'social' focus for rangelands research is therefore to identify key environmental values and to reduce associated measurement problems to facilitate the introduction of rights-based policy measures.

#### RECENT DEVELOPMENTS IN TAXATION

Rural taxation policy consists of a series of special provisions, some of which can be justified on efficiency grounds due to the unique circumstances of agriculture, and some of which represent a subsidy. The difficulty of tax reform is that removing private benefits in the form of subsidies in exchange for longer term efficiency gains is difficult to 'sell', having little reference to equity considerations, such as maintaining the 'family farm'.

There is, however, increasing interest in pursuing efficiency gains in agricultural policy, if for no other reason than budgetary considerations. The current pursuit of efficiency in agriculture by government manifests itself in more palatable terms such as 'encouraging financial self-reliance' and 'improving risk management'. Given the need to ensure consistency in policy signals to the rural sector, particular emphasis is being placed on the complementarity of policies, such as rural taxation and adjustment policy, and on the complementarity of the sub-components of these policies.

To achieve greater efficiency in resource use in the rangelands, time could be spent on examining the extent to which special taxation provisions for primary producers, outlined below, discourage improved management practices, such as strategic grazing and the development of off-farm income.

# Special Provisions for Primary Producers

- Profits from forced sales of livestock, from compensation for death or compulsory destruction of livestock and disposal of livestock necessitated by fire, flood or drought or from insurance recoveries on loss of livestock, are taxed on a concessional basis.
- Profit from sale of double wool clips necessitated by fire, flood or drought to be deferred until next year.
- Concessional provisions relate to the treatment of livestock, as distinct from other trading stock in calculating a primary producer's taxable income.
- The income tax of primary producers may be eligible for averaging rebates or complementary tax payable.
- Tax deductibility of deposits to the IED scheme with corresponding assessment when the deposits are withdrawn.
- Deduction over 3 years for costs of conveying or conserving water.
- 100% deduction for costs of preventing land degradation.

Some more specific areas of taxation reform that are currently being considered include the following.

\* Income Averaging. Averaging is designed to reduce the additional tax burden imposed on individuals with fluctuating incomes due to the progressive tax system. It is only available to the rural sector.

Recent analysis, however, (see Douglas and Davenport 1993) indicates that income averaging may have undesirable side effects, such as:

- exacerbating financial risk by reducing tax payments in good years and increasing tax payments in bad years;
- reducing the benefit of concessions such as livestock elections, sections 75B/D and IED's by reducing marginal tax rates;
- discouraging the development of diversified investment portfolios due to shading in provisions associated with off-farm income distorting marginal tax rates applying to off-farm income;
- providing windfall benefits to high income earners at the expense of low income earners, thus being inequitable; and
- reducing the efficiency of investment decisions by lagging tax benefits, such as those for conservation works, over 5 years.
- \* Income Equalisation Deposits. Government currently provides two subsidised deposit schemes to the rural sector which are not provided to other sectors, the IED and Farm Management Bond Schemes. The existence of alternative, but similar, schemes is considered to cause confusion among producers. Furthermore, producers and their advisers appear to have little appreciation of the risk management benefits that contingency funds can provide.
- \* Sections 75B/D. This section of the ITAA will be reviewed in 1994-95. Given the inefficiency associated with subsidies it may be more appropriate for scarce finances to be targeted through a system of grants. Options such as tax rebates and credits are currently being debated as alternatives to sections 75B/D concessions.
  - In relation to revenue foregone, a US study in which the impact of policy measures that more closely matched government subsidies to the marginal cost of actual erosion reduction, found that government outlays could be reduced by about 70 per cent for the same level of soil loss reduction (Dumsday and Seitz 1985).
  - These sections may also provide a double tax deduction, once from income tax and once from capital gains tax.
- \* Livestock Valuation. Producers are able to value natural increase at values which may be below production costs resulting in:
  - tax liability being deferred until stock are sold, thus reducing incentives to destock in response to drought. Not only does this place increased pressure on the resource base, but may result in producers selling stock later than otherwise, at depressed prices;
  - the need for special provisions (elections) to enable farmers to defer tax when destocking occurs in response to fire, flood or drought.
- \* Treatment of Losses. Production losses can be carried forward to offset income earned in future years. The lag in receiving the benefit reduces the value of the benefit, and the size of the benefit received varies according to the level of income earned in the year the loss is recouped.

# CONCLUSION

Land degradation in the rangelands owes much of its presence to 'industry capture' of governments, land administrators and researchers. Rent seeking behaviour by incumbent pastoralists has been supported by the political imperative of government and the populist approach of industry and government funded advisers. The outcome has been excessive concern with equity and the family farm, rather than efficiency, with the resultant effect of subsidisation being adjustment and resource degradation problems.

Taxation concessions in their various forms have undoubtedly contributed to this process. Taxation policy is designed for revenue raising and income redistribution purposes, rather than bridging the gap between the marginal private and social costs of resource use. Taxation concessions such as sections 75B/D are likely to be widening this gap rather than reducing it, by rewarding rather than penalising inappropriate management practices.

As well as being inconsistent with the 'polluter pays' principle, taxation concession are a blunt instrument involving a significant opportunity cost in terms of foregone revenue and subsequent gains that may be achieved through more targeted policy instruments.

A more important issue in relation to the sustainable use of the rangeland resource is for government to be explicit about policy objectives. It makes little sense to assess policy options such as rural taxation, without first being clear about desired outcomes.

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# APPARENT SUPPRESSION OF WESTERN MYALL (ACACIA PAPYROCARPA BENTH.) COHORTS PRIOR TO THE ARRIVAL OF SHEEP IN THE ARID RANGELANDS OF SOUTHERN AUSTRALIA

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#### **ABSTRACT**

The introduction of sheep grazing across the arid rangelands of southern Australia was not sudden but progressive as water points were gradually created and large areas subdivided into smaller and smaller paddocks. Thus there are areas grazed today that were beyond the range of grazing sheep in the past. Sheep are known to be capable of destroying new cohorts of many perennial arid zone plants, including *Acacia papyrocarpa* Benth. (the western myall) which recruits only episodically (about four times a century) after huge rains. Thus if sheep were the sole destroyers of western myall seedling cohorts, past populations should have survived in sites where sheep did not then graze. Preliminary investigations using this new concept (which we introduce as the "fossil" paddock idea) indicate that whole cohorts of western myall failed to persist at Middleback, South Australia, even in the absence of sheep grazing. The "fossil" paddock approach should be widely useful and we shall refine it over the next two years.

### **INTRODUCTION**

During the past few years it has become more apparent to us just how many factors can threaten recruitment of *Acacia papyrocarpa* Benth. (the western myall) and many other arid zone perennials. There appears to be little evidence that points exclusively to any one factor (Lange and Purdie 1976; Lange and Graham 1983; Tiver, 1992). Undoubtedly, recruitment in the western myall itself has been moderately to severely suppressed since the introduction of introduced herbivores - rabbits and sheep (Lange and Purdie, 1976; Lange and Graham, 1983); however, kangaroos are also present in the western myall woodlands in much larger numbers than in the pre-pastoral era (D.A. Nicolson, *pers. comm.*). Just how best to manage the western myall woodlands to sustain the populations of the western myall and other perennial tree species is problematic; and our uncertainty regarding the effects of introduced and native herbivores upon the populations does not help matters. With this in mind we have begun to investigate the historic effects of sheep on the recruitment of western myall.

# Western myall population structure

Perennial plants are difficult to age. In the case of western myall the best approach is life stages (Lange and Purdie, 1976). The senior author has refined their approach, identifying nine distinct life stages. Morphological changes that occur as the western myall grows older (Figure 1) are relatively easy to observe and distinguish. Using this simple technique, individual trees can be assigned with reasonable confidence to one of the nine stages, particularly within a site.

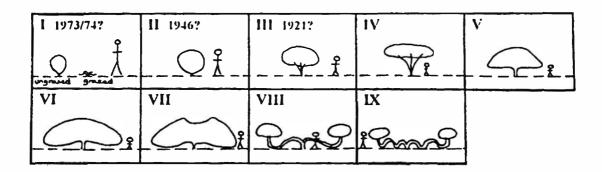


Figure 1: Life stages of the western myall

# Episodic recruitment

A characteristic of Australian arid zone perennials such as the western myall is the episodic nature of recruitment events after major inundations. These events occur approximately four times per century in the Whyalla area (Lange, 1971); the last three within living memory being in 1921, 1946 and 1973/74. Each resulted in a major emergence of western myall seedlings in the Middleback area; in the intervening years, little if any recruitment occurred in the open paddocks (Lange and Purdie, 1976; R.T. Lange. D.A. Nicolson and A.D. Nicolson *pers. comm.*). These three cohorts can be recognised and assigned to Life Stages I (1973/74), II (1946) and III (1921); examples can be found throughout the region.

# The "fossil" paddock hypothesis

Because introduced herbivores can destroy whole cohorts, their impact, and its timing, is evident in population structures of arid zone plants (*Acacia burkittii*, Crisp and Lange, 1976; *Acacia sowdenii* [syn. *papyrocarpa*], Lange and Graham, 1976). However, domestic stock did not impact all of the landscape simultaneously. At the start, much of the landscape was beyond the reach of stock due to water and paddock restrictions. *Thus, the impact of stock was progressive - not sudden*. Lange, Nicolson and Nicolson (1984), describe the progressive subdivision of paddocks and water-point proliferation on Middleback which still continues today after almost 70 years. *We have thus coined the term "fossil" paddock to describe any paddock that has had a new pattern of smaller paddocks and new watering points superimposed upon it.* 

Within eight to ten years of recruitment, juvenile western myalls should have grown too tall for sheep to suppress them; e.g. western myall recruits from the 1921 cohort (and other perennial tree species) on Yudnapinna Station some 100 km to the north were not suppressed by the introduction of sheep some ten years after a major fire destroyed most of the original vegetation (A.D. Nicolson pers. comm.). Given the above, and given that sheep rarely venture further than 5 km from water (Lynch, 1974), then if sheep are the prime cause of non-recruitment in the western myall, the appropriate life stages will be present in areas of the "fossil" paddocks that were beyond the grazing range of sheep when that cohort was establishing and will be absent within the grazing range of those sheep. Thus, Stage III (1921) western myalls should be present on Middleback around waters opened after 1929, and Stage II (1946) present for waters after 1954. Stage I (1973/74) should be scarce in most places because few would have escaped sheep grazing. If sheep are the culprits this sort of pattern may recur continuously across the pastoral zone with different permutations. However if sheep are not the prime destroyers of western myall seedling cohorts, then this pattern will not be found.

#### **METHODS**

The site chosen for the initial investigation was an area of western myall low open-woodland between the homestead at Middleback Station and the city of Whyalla on the northern Eyre Peninsula of South Australia (32°57'S, 137°24'E). Western myall is the dominant overstorey species; the understorey is characterised by the chenopod shrubs *Maireana sedifolia*, *M. pyramidata* and *Atriplex vesicaria* and an ephemeral flora of forbs and grasses.

A "fossil" paddock which we refer to by its former name of Mount Laura Paddock (Figure 2) was located on Middleback Station; we used this paddock to test this idea for the first time - further paddocks will be examined in due course. Mount Laura Paddock, although fenced around its perimeter and bisected by the unfenced Whyalla to Iron Knob Ore Haul Tramway, remained ungrazed until 1929 when two new waters were added to the north-western corner and to the western boundary. During the period 1958/60 Mount Laura "fossil" paddock was subdivided into four smaller paddocks - Rainbow, Koleroo, Moonee and Wanga; other dams and pipelines were added at about this time. Thus, the 1921 cohort should have escaped sheep grazing and occur throughout the entire paddock; and in areas more than 5 km from the original two watering points, the 1946 cohort should also have escaped sheep grazing.

Along the internal tracks of Mount Laura Paddock, ten sites were chosen at locations where there were between 50 and 100 western myall trees. Unfortunately only three of these sites (5, 9, and 10) were able to be located in the part of the paddock that was more than 5 km from the original water points. As a control we used three sites (scored for a previous experiment) in an adjacent paddock that has

been heavily grazed by sheep since at least 1919 (A.D. Nicolson *pers. comm.*). A total of 994 trees in Mount Laura "fossil" paddock was scored and 331 for the control paddock. Furthermore, whilst driving around the paddock we also looked carefully for western myall trees from Life Stages II and III.

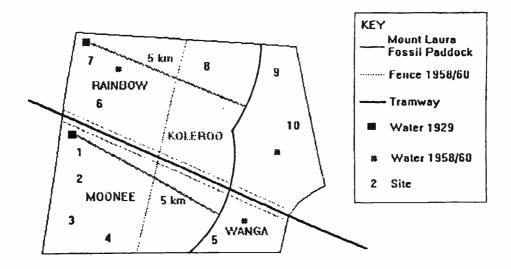


Figure 2: Mount Laura Fossil Paddock

#### RESULTS

# 1921 cohort - "Stage III"

Virtually none of the 1921 cohort was found in Mount Laura Paddock; only seven of the 994 trees were of Stage III (Table 1). This was similar to the control sites grazed since at least 1919. Table 1: Life Stages at ten sites in Mount Laura Paddock and at three sites in the control paddock.

Life Stage	Mt. Laura - 10 Sites Percentage of Trees	Control - 3 Sites Percentage of Trees  00.0% 00.0% 00.9% 99.1%		
I II III IV to IX	00.1% 00.0% 00.7% 99.2%			
TOTAL	994 trees (100%)	331 trees (100%)		

# 1946 cohort - "Stage II"

None were found at any site, Mount Laura or control (Table 1). Indeed, in Mount Laura Paddock as a whole, few western myall were observed which could confidently be placed in Life Stages I, II or III.

# **DISCUSSION**

Thus, assuming significant numbers of the 1921 and 1946 cohorts germinated, it seems that most failed to persist even in the absence of sheep grazing. It appears from the preliminary results obtained that, at least for Mount Laura Paddock, the 1921 and 1946 (and 1973/4) cohorts are essentially missing from the record despite the absence of sheep until 1929, eight years after the 1921 cohort recruited to the population. Thus it seems unlikely that sheep introduced into Mount Laura Paddock in 1929 would be able to destroy the majority of the then eight-year-old 1921 cohort, or the 1946 cohorts in the three sites beyond the range of grazing sheep. Some other agent must have been responsible for the scarcity of the 1921 and 1946 cohorts, possibly rabbits or kangaroos.

As this research is only in its infancy the findings are far from conclusive. Several other "fossil" paddocks both on Middleback and on adjacent Nonowie Station to the south have been inspected; few plants of the 1921 or 1946 cohorts could be found, from which we infer that few survived there also. As we continue the research to include many more "fossil" paddocks across the western myall woodlands, the generality of our findings will become clearer.

This historical ecology approach should be widely applicable to discovering the responses of other long-lived perennials to the effects of herbivores in the arid zone.

#### **ACKNOWLEDGMENTS**

The work is being conducted as part of a PhD study within the Middleback Field Centre Program. We would particularly like to thank the Nicolson families, not only for their generous hospitality at Middleback and Roopena Stations, but also for their valuable insights and contributions to this work. Thanks are also due to Dr R.T. Lange for his enthusiastic encouragement. The work is ongoing and is funded by a Wool Research and Development Corporation Scholarship and a small grant from the Sir Mark Mitchell Bequest, both awarded to the senior author.

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# RELATIONSHIP BETWEEN STOCKING INTENSITY AND THE SOIL SEED BANK OF A SEMI-ARID RANGELAND

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#### **ABSTRACT**

Spatial variation in the seed bank of a semi-arid *Eucalyptus populnea* woodland along a gradient of stocking pressure, away from a water source, was investigated. The seed bank was very diverse and abundant (9,047-17,261 seeds/m²) and three annual forbs (*Crassula sieberana*, *Wahlenbergia tumidifructa* and *Dysphania glomulifera*) contributed over 80% of the seed bank. Most species showed spatial variation in their seed distribution correlated with stocking pressure. The implications of this for grazing management are considered.

#### INTRODUCTION

The soil seed bank of a community contributes significantly to the ability of that community to regenerate and also to the distribution pattern of the vegetation (Coffin and Lauenroth 1989). Conversely the vegetation, and its seed production in particular, influences the composition and abundance of the seed bank (Rabinowitz 1981).

In semi-arid rangelands under increased grazing pressure there is usually a decline in the density and basal area of perennial grasses, coupled with an increase in the population of winter and summer annuals and woody species (O'Connor and Pickett 1992). The effects of grazing on the seed bank are usually similar (Johnson *et al.* 1969). The interaction of stocking pressure and soil seed bank composition is, therefore, of great importance in the ecology of grazed pastures where stock management is one of the few economically viable methods for pasture management.

The aims of this study were, therefore, to: 1) determine the germinable soil seed bank of a semi-arid rangeland along a gradient of stocking intensity, and; 2) document spatial variation in the distribution of species found in the seed bank as a result of the stocking pressure gradient.

# **METHODS**

A 75 ha study area, was located in a paddock at North Yancho, S.W. of Bollon, Qld (147°13'E, 28°16'S). Annual average precipitation is about 450mm, however during the two years prior to the collection of field samples only 494mm rainfall in total was recorded. The vegetation at the site is a *Eucalyptus populnea-Eremophila mitchellii* open woodland in which perennial grasses dominate the ground layer. The paddock has been subjected to moderate levels of grazing by sheep for decades which has influenced the plant distribution, especially in relation to a bore-drain, which runs adjacent to the western fence of the paddock. The paddock is uniform in other respects so any observed trends may be related to stocking pressure.

A transect 500m X 1500m, perpendicular to the bore drain, was divided into six sections. In each of the six sections thirty  $1\,\mathrm{m}^2$  quadrats were located from which five soil cores 5cm diameter and 3.5cm deep were collected in March 1993 and then pooled. These samples were used in germination trials to determine the seed bank. The significance of differences in seed bank sizes was determined with chi squared analysis or Fishers exact test.

#### **RESULTS**

The seed bank contained 71 species, with 32-35 species in each of the transect sections. Annual and biennial species dominated the seed bank and contributed 96.9% of the total, with *Crassula sieberana* (35%), *Wahlenbergia tumidifructa* (32%) and *Dysphania glomulifera* (15%) being particularly abundant. There was an average abundance of 13,027 seeds/m² over all sections.

The size of the seed bank differed significantly between sections (Table 1), with the highest densities close to the bore-drain, but not directly adjacent to it. All common species except Sclerolaena birchii

showed a significant relationship between seed density and distance from the water source. The spatial variation exhibited could usually be matched to the categories employed by Van Rooyen *et al.* (1991) to describe the spatial variation of plants across a grazing intensity gradient for use in range condition assessment.

Table I. Seed density (seeds/ $m^2$ ) in the seed bank of six sections along a gradient of stocking intensity.

	Section					
	1	2	3	4	5	6
Size (ha)	0.5	1	3.5	20	25	25
Number of Species	32	35	34	33	32	33
Species						
Bergia trimera⁴	96	655	246	41	27	27
Calandrinia pumila	l	191	55		14	
Chenopodium cristatum	491	409	109	123	246	96
Chenopodium melanocarpum	109	109	96		27	27
Crassula sieberana•	4912	7832	3466	3248	1965	3261
Dysphania glomulifera³	901	1637	4448	2743	136	805
Eragrostis lacunaria	55	109	55	14	14	14
Eragrostis microcarpa³		14	55	164	14	27
Erodium crinitum <sup>1</sup>				27	82	287
Hyalosperma semisterile³		205	409	314	41	41
Plantago debilis⁴	41	273	55	82	68	27
Plantago turrifera	177	191	55	150	382	246
Sclerolaena birchit	246	205	82	177	109	177
Stuartina muelleri		396	205	450	68	355
Wahlenbergia tumidifructa²	641	1242	2661	7082	5567	5144
Others	587	532	544	708	356	437
Unknown*	791	1501	1706	1938	791	1228
Total	9047	15501	14247	17261	9907	12199

Note:

- <sup>1</sup> = Category 1 Species
- = Category 3 Species
- = Does not fit a Category
- = No significant spatial variation
- \* = Seedlings died before they could be identified

# **DISCUSSION**

The seed bank diversity (71 species) is extremely high when compared with other studies (Rabinowitz 1981; Johnson *et al.* 1969). A study conducted in a similar community in New South Wales found only 47 species (Hodgkinson *et al.* 1980). The large area over which the soil cores were collected could be expected to increase the number of species detected, while grazing is also known to increase species diversity (Gibson and Brown 1991). The diversity of the seed bank of each individual section is similar to other studies. This suggests that the heterogeneous conditions caused by the gradient in stocking pressure at this site is the major factor contributing to the high diversity recorded.

<sup>2</sup> = Category 2 Species

4 = Category 4 Species

Annuals formed the vast majority of the seed bank, perhaps the consequence of the high stocking pressure, as annual weeds tend to become prominent in the seed banks of heavily grazed sites (Johnston *et al.* 1969).

Grasses constitute only 1.1% of the seed bank despite their domination of the ground vegetation. That grasses often become less prominent in the seed bank when vegetation is grazed (Johnston *et* 

al. 1969), coupled with their tendency to be under-represented in seed banks (Bertiller 1992) may explain their rarity. Thyridolepis mitchelliana is one of the dominant grasses in natural Eucalyptus populnea woodlands, but it is sensitive to heavy grazing and, as a result of this, its abundance in the rangelands is often diminished. T. mitchelliana provides a forage preferred by sheep and is important in maintaining the viability of pasture, however it was absent from the seed bank at this site. Hodgkinson et al. (1980) also noted that although T. mitchelliana was common in the vegetation it was absent from the seed bank.

The dominant grass of many grassland and woodland communities worldwide is often extinction prone (South Africa: O'Connor and Pickett 1992; North America: Coffin and Lauenroth 1989; South Africa: Bertiller 1992). This dominant, extinction prone species usually possesses the same syndrome of life-history characters: it is palatable, a long-lived perennial, an obligate seed producer, produces low numbers of large diaspores, is poorly dispersed, and is not persistent in the seed bank. Species possessing such a set of characters can become locally extinct in areas that experience droughts and sustained heavy grazing (O'Connor and Pickett 1992). T. mitchelliana possesses the above list of characters and should be considered an extinction prone species. Paddocks, therefore, should be rested from grazing once droughts break to allow Thyridolepis to seed freely and regenerate. If grazing continues without resting after droughts the local extinction of Thyridolepis may result.

The seed bank is indicative of the regenerative potential of a site and is important for the conservation of a community. Studies of the seed bank may give a more accurate assessment of range condition and provide additional information which cannot be ascertained from the vegetation alone.

#### **ACKNOWLEDGMENTS**

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# ASPECTS OF POST-FIRE REGENERATION IN SOFT SPINIFEX (TRIODIA PUNGENS) COMMUNITIES NEAR NEWMAN, WESTERN AUSTRALIA

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#### **ABSTRACT**

Two aspects arising from an opportunistic study of post-fire regeneration in soft spinifex are discussed. Fire generally destroyed adult spinifex plants, and it appeared that there would have been little replenishment of the seed bank until at least 3-6 yr after fire. This may have implications for the frequency of any prescribed burning which may be contemplated. Preliminary observations suggested that harvester ants, particularly of the genus *Meranoplus*, might play an important if accidental role in positioning spinifex caryopses ('seed') giving rise to post-fire seedling establishment.

#### INTRODUCTION

Soft spinifex (*Triodia pungens* R.Br.) is a perennial hummock grass widely distributed across the arid tropics between the Western Australian coastline and eastern Queensland. A number of different forms have been described (Burbidge 1944a). Resin from this species was highly valued in traditional Aboriginal culture (Latz 1982). Soft spinifex grasslands often exhibit a sparse shrub or tree layer. Such communities provide important habitats for native fauna (Burbidge and Pearson 1989) and can provide a valuable drought reserve in pastoral areas (Suijdendorp 1969). Early post-fire regrowth is attractive to native and introduced animals alike. Fire generally kills adult plants in the inland Pilbara (Burbidge 1944b). In spinifex generally, succession after fire appears to follow a relatively predictable course (Griffin 1984).

In this paper I will present two aspects of a recent study of ungrazed spinifex communities near Newman, in the south-eastern Pilbara of Western Australia. Newman, the township supporting the nearby mining operations of BHP Iron Ore Ltd., lies just north of the Tropic of Capricorn, about 230 km SSE of Port Hedland. Mean annual rainfall is 311 mm, mainly associated with thunderstorms and cyclonic activity during the December-March period. Some winter rainfall is expected as cold fronts penetrate northwards. Humidity is generally low, and evaporation rates are high (annually >3700 mm, Class A pan). Mean daily temperatures are highest in January (38°C maximum) and lowest in July (8°C minimum). Soft spinifex communities close to Newman occur most commonly as small patches (typically 0.1-1 ha), often associated with minor drainage systems, where direct rainfall is supplemented by run-on from nearby upslope areas.

# **METHODS**

Seven sites, with time since fire varying from zero to >15 yr (Table 1), were selected opportunistically on the basis of expert local knowledge. The two oldest sites were situated within 50 m of each other, but appeared to vary in amount of run-on received. Altitudes of sites ranged between 510 and 580 m above sea-level and slopes were either level or very gently inclined. Soils from inter-hummock spaces were classified in most cases as loamy sands. Mean laboratory pH values (1:5 in 0.01M CaCl<sub>2</sub>) were in the range 5.7-6.0. A few feral horses and cattle were present in the general area, but there were no indications that stock were grazing the study sites. Permanent plots were established (minimum size 30 x 30 m). These were monitored each July and December between July 1988 and July 1990. It was necessary to vary quadrat size across sites from 1 x 1 m to 2 x 2 m to suit the wide variation in hummock dimensions. Rainfall records were obtained from Newman Post Office. Predictions of soil moisture availability from the water balance model WATBAL (Keig and McAlpine 1974) were also used for interpretation of vegetation data.

During quadrat sampling of plots, the number of inflorescence stems on *T. pungens* hummocks was recorded as evidence of previous flowering. Spinifex inflorescence stems may last for two years or more (Jacobs 1984). Once counted, stems were broken or detached so that, in permanent quadrats, any found on the next occasion were attributable to the intervening period.

In July 1990, three T. pungens juveniles were carefully excavated from the area around an arbitrarily

selected burnt hummock in each quarter of site NOV89. The plants were pressed and subsequently examined with a dissecting microscope. Specimens previously collected in Jan. 1998 from site JAN88 were also examined. In some specimens there was an attached remnant of the palea or lemma; in others a characteristic kink was present between the rhizome (arising from the epicotyl) and the seminal root, corresponding to the original position of the caryopsis ('seed'). The caryopsis burial depth was taken to be the distance between the first tillering node and the observed or inferred position of the caryopsis. General observations were made of harvester ant activities on the sites.

#### **RESULTS**

In sites observed during early post-fire stages (all following summer fire) virtually all adult plants had been killed within burnt patches. As expected there was no evidence of flowering in the recently established spinifex stand at the NOV89 site. At site NOV88 about 5% of hummocks flowered between Dec. 1989 and July 1990, little more than one year after fire, but the areal density of inflorescence stems was negligible (Table 1). There was no evidence of any flowering at site JAN88 during the first 30 months after fire. Production of inflorescence stems at sites NOV86 and SUM84 followed similar trends, with very low densities up to Dec. 1989, and dramatic increases to 25-30 stems/m² over the interval to July 1990. Densities at these sites were then comparable with that in the long unburnt site PRE75B. The two long unburnt sites were compared only in Dec. 1988 and Dec. 1989. On these occasions they differed significantly in inflorescence production, the mean density at PRE75A being more than twice that at PRE75B.

According to Newman Post Office records, annual rainfall was about average in 1988 and below average in 1989. In 1988, January rainfall was much below average while March and May rainfalls were very much above average. In 1989 above average and very much above average rainfalls were received in April and June respectively. In 1990 rainfall was very much above average in January, but there was no effective autumn or winter rain. The WATBAL model predicted three successive 5-day periods of available soil moisture in early 1990, which was thus more favourable in terms of summer rainfall than 1988 and 1989, when soil moisture was available only transiently.

All plants excavated from site NOV89 were positively identified as seedlings. For the NOV89 specimens, it was estimated that the mean caryopsis burial depth (CBD) was 15 mm (n=12, s.d. 5). The mean CBD of seedlings collected from the JAN88 site was 11.5 mm (n=6, s.d. 3.5).

Table 1. Inflorescence stem density (stems/ $m^2$ ) on successive sampling occasions. Data shown for Dec. 1988 onwards apply to permanent quadrats (sample size = n).

Site	n	Last fire	July '88	Dec. '88	July '89	Dec.'89	July '90
NOV89	40	Nov. 1989	-	<u>-</u> .	-	0	0
NOV88	40	Nov. 1988	-	0	0	0	<0.1
JAN88	28	Jan. 1988	0	0	0	0	0
NOV86	28	Nov. 1986	0.2	0.8	3.9	1.3	26
SUM84	28	early 1984	0.3	< 0.1	1.8	0.8	29
PRE75A	48	before 1975	-	16.5	-	23	-
PRE75B	28	before 1975	-	8.9	12	9.6	25

At site NOV86, fallen spinifex spikelets were first observed in July 1990, concentrated in depressions. A few middens surrounding nest entrances (not raised) were also found at that time. Middens consisted mainly of the remnants of *T. pungens* florets. There were also some intact florets (sometimes aggregated) which occasionally contained a developed grain. Solitary slow-moving ants, later identified as *Meranoplus* sp. were observed transporting spikelets over a distance of 10 m before entering one such midden. The same species was also found within a few weeks of fire at sites NOV88 and NOV89. There were a few middens of the same type at the SUM84 site in Dec. 1988 and subsequently. Middens were particularly common and impressive in size at PRE75A, the site having the greatest spinifex cover (about 25%). While *Meranoplus* appeared to be gathering most of the fallen spikelets, nest entrances associated with other ants also incorporated such material.

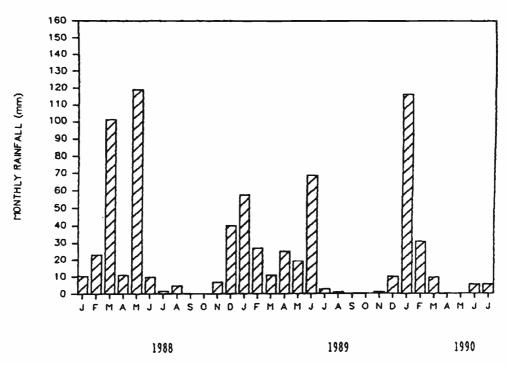


Figure 1. Monthly rainfalls over the period January 1988-July 1990 (Newman Post Office).

#### **DISCUSSION**

The destruction of *T. pungens* adults by fire means that seedbank characteristics are critical to rapid regeneration in the environment studied. In spinifex, the observation of inflorescence stems does not necessarily imply the production of viable seed, since seed-set may not occur (Jacobs 1984). However the relatively strong flowering between Dec. 1989 and July 1990 at sites NOV86, SUM84 and PRE75B indicated the potential for significant seed production at these sites. This was consistent with the general propensity for summer flowering among *Triodia* species (Jacobs 1984). At the NOV86 and SUM84 sites this flowering occurred during the fourth and seventh summers respectively, since fire. The SUM84 site had maintained a relatively constant projected cover of spinifex throughout the study (17-18%). This was similar to the live cover of the long unburnt site PRE75B (16%) and to the level at NOV86 in July 1990 (16%). It seemed conceivable that the SUM84 and NOV86 stands might have been able to carry a fire before effective replenishment of the seedbank, although this would need further investigation.

Observations suggested that *Meranoplus* sp. ants may be important as agents influencing the size and perhaps also the disposition of the *T. pungens* seed bank in the Newman communities. These ants appeared to gather considerable volumes of fallen florets and often constructed chambers within one or two cm of the surface. This was comparable to the depth of those caryopses giving rise to established seedlings.

#### **ACKNOWLEDGEMENTS**

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### INDICATORS FOR RANGE ASSESSMENT

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#### **ABSTRACT**

Indicators for range condition assessment have been identified in South Australia's northern cattle rangelands, the first time this has been done for the region. The most reliable method proved to be the use of defoliation ratings via rapid field survey recorded radially from water. Quadrat based sampling techniques were used to define grazing gradients but their application was limited in northern South Australia by the spatial heterogeneity inherent to many range types, the unreliable trends which can be obtained and the time needed to find and then sample suitable uniformly vegetated sites. Other methods such as relocation of historical photographs and cross fence comparisons do provide information on indicators and were successfully used during this study to supplement information acquired from quadrat based methods. However, exclosures, photopoints and tagging of perennial plants were of little value to this study due to lack of impact by cattle, as a consequence of favourable seasonal conditions in the study area.

In the light of our experience with intensive quadrat based methods we would recommend that indicators of range condition be determined by rapid field survey methods combined with the knowledge of local pastoralists rather than by the use of laborious quadrat based methods.

#### **INTRODUCTION**

The South Australian Pastoral Land Management and Conservation Act (1989) requires that a program of lease assessment for range condition, identification of any problem areas and determination of carrying capacities be completed by 1998. However, the necessary information required to achieve this for South Australia's northern rangelands does not exist. This project initiated the collection of data on this area specifically for range condition assessment.

The South Australian Department of Environment and Natural Resources has developed a range assessment methodology to satisfy the requirements of the Act, utilising the concept of a Land Condition Index. Determining this index requires a knowledge of the range condition indicators for each range type, i.e. which species increase under grazing and which species disappear.

The selected study area consisted of three cattle leases in far northern South Australia, approximately 1000 km north of Adelaide. The region is defined as arid and has a mean annual rainfall of approximately 150 mm.

In the southern sheep rangelands where the index was developed, the vegetation is fairly uniform and therefore traditional piosphere principles apply, i.e. the grazing gradient is linear and centres on the watering point. However, in at least parts of the northern cattle rangelands the pattern of vegetation is not uniform but more a mosaic of several vegetation types of differing palatability occurring in patches.

The task therefore was largely to devise a technique which can be used to discern the piosphere effect in these patchy areas so that the indicators of range condition could be identified and described.

#### **METHODS**

Three major methods were used to derive range condition indicators, all predicated on the trend of increasing stocking impact with proximity to water: -

1) The trends of frequency of occurrence of perennial plants along radial traverses from four permanent watering points were analysed by a binomial logistic model.

- 2) Density and cover of perennial plants and of litter cover were analysed visually, by regression and from interpretation of field notes.
- 3) A defoliation index was developed which enables fast and accurate documentation of the preference cattle have for particular plant species. It is known that those plants most palatable to livestock usually decrease while those not palatable usually remain static or increase in abundance. Information gained from this index provided support for results from the quadrat sampling techniques and information to pastoralists on the palatability of plants.

Supplementary studies included the establishment of exclosures and photopoints to document the recovery of grazed areas after rain. Exclosures also highlight the preference cattle and rabbits have for particular plant species and for the degree of grazing on them.

Other supplementary studies involved the analysis of cross fence differences, re-location of scenes from old photographs which show stock induced changes over time and tagging of perennial plants to determine their palatability and the impact of cattle on them.

**RESULTS**Some of the main indicators found were:

Scientific name	Response to grazing	Common name	Range type
Acacia aneura (juvenile)	Increase	mulga	Mw,Sd
Acacia aneura (mature)	Decrease	mulga	Mw,Sd,P
Acacia ligulata	Increase	sandhill wattle	Mw,Sd
Acacia tetragonophylla	Increase	dead finish	Mw,P
Astrebla pectinata	Decrease	Mitchell grass	O,P
Atriplex vesicaria	Decrease	bladder saltbush	O,P,C
Enchylaena tomentosa	Decrease	ruby saltbush	Mw,Sd
Eragrostis eriopoda	Decrease	woollybutt	Mw
Eragrostis setifolia	Increase	neverfail	O,P
Eremophila gilesii	Increase	green turkey bush	Mw
Eremophila latrobei	Decrease	crimson turkey bush	Mw,Sd
Eremophila macdonnellii	Inerease	fuchsia bush	Mw
Maireana astrotricha	Decrease	low bluebush	С
Monachather paradoxa	Decrease	bandicoot grass	Mw
Panicum decompositum	Decrease	native millet	O,P
Rhagodia spinescens	Decrease	thorny saltbush	Mw,Sd
Senna artemisioides ssp. artemisioides	Increase	silver cassia	Mw,Sd
Sida ammophila	Increase	sand sida	Mw,C
Solanum ellipticum	Increase	velvet potato bush	Mw,Sd
Sporobolus actinocladus	Decrease	katoora	O,P

#### \* Range type

- 1: O = Oodnadatta saltbush tableland
- 2: P = Atriplex vesicaria and Astrebla pectinata plains and plateaux
- 3: Mw= Mulga perennial grass woodland
- 4: C = Maireana astrotricha / Atriplex vesicaria calcareous flats
- 5: Sd = Acacia aneura / Acacia ligulata sand dunes

#### **DISCUSSION**

Eight field methods were used to determine indicators of range condition during this study. In light of this study we now know that indicators can be quickly and reliably determined using a combination of palatability ratings, the knowledge of pastoralists, cross fence comparisons, the literature and astute field observations.

These five methods of determining indicators provided more reliable information on indicators than did laborious quadrat based sampling techniques.

Whilst it is true that quadrat based sampling techniques did determine indicators, their value was substantially restricted by the heterogeneity of vegetation, inconsistent trends which were sometimes depicted and by the amount of time needed to collect, collate and analyse the data.

Photopoints, exclosures and tagging of plants were also of little value for determining indicators in the short term as they were influenced by seasonal conditions, but they might be useful in the long term. Historical photographs were also of little value because they were hard to relocate and usually only showed areas of severe stocking impact.

The methodology we would use to determine indicators of range condition is first, to familiarize ourselves with the more common plants in the region to be studied and second, seek the opinion of local pastoralists who usually have a knowledge of the preference their livestock have for the more common plants of the region.

Pastoralists can also provide information on the effect of geographical and seasonal conditions on plants and historical information which is not available from other sources. The reliability of this information does however vary between pastoralists. Therefore other field methods should be used to collect additional information to substantiate information already obtained. These methods include the use of palatability ratings via rapid field survey, cross fence comparisons and astute field observations.

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#### LANDSCAPE EVOLUTION ON THE BARKLY TABLELAND

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#### **ABSTRACT**

A continuing program of land resource assessment on the Barkly Tableland has resulted in an increased level of understanding of the landscape diversity and the processes past and present that have shaped the area. In particular, it has been recognised that parts of the landscape are dynamic, but that the processes in action are quite different to those that operate in more topographically varied regions. Gilgai development is the surface expression of these processes. An understanding of landscape genesis and diversity reveals that some pastures composed of annual species are soil and landform specific, and not an indication of loss of perennial grasses. However, changes in the perennial/annual composition in other pastures may reflect the effects of grazing. It seems the dominant effect of over-utilisation is an increase in unpalatable forbs.

#### **INTRODUCTION**

The Barkly Tableland occupies an area of about 100,000 km² in the central east of the Northern Territory extending into Queensland. It is characterised by extensive flat to gently undulating 'black soil' plains dominated by mitchell grass (*Astrebla* spp). At first appearance the plains appear to be uniform - a waving sea of grass only broken by the occasional bare stony rise and scattered coolibahs lining some of the larger drainage features. Certainly in contrast to more dramatic landscapes, such as those of central Australia, the Barkly Tableland lacks variation. However, the CCNT program of land resource assessment that began in 1988 and accelerated in 1992 with National Landcare Program assistance, has concluded that this apparent uniformity and the concept of a totally stable landscape is a matter of scale and perception. The landscape is diverse and subject to active erosional and depositional processes, but via quite different mechanisms which are a function of a unique geological history, soil type, climate and most importantly lack of slope.

The title 'Barkly Tableland' is a misnomer. The region is not a tableland being neither more elevated than the surrounding country nor distinctly marked by a relatively sharp rise in elevation at its margins. 'Barkly Plain' is a more appropriate term, and will be used from here on in this discussion.

# SETTING THE SCENE

A brief summary of the geological history of the Barkly Plain is essential to set the scene for an understanding of the more recent geomorphological events that have shaped the area. The Plain is predominantly formed over middle Cambrian (ca. 520 Ma) dominantly carbonate sedimentary rocks of the northern Georgina Basin (Smith, 1972). Parts of the northern region of the Plain have a thin cover of Cretaceous marine sediments over the Cambrian rocks. The Georgina Basin is a Palaeozoic intracratonic downwarp that straddles the contacts of several Proterozoic basement terranes - the Tennant Creek Inlier, the McArthur Basin and the South Nicholson Basin. These terranes form low ranges and hills of metamorphic, sedimentary and granitic rocks where they are exposed in the Tennant Creek and Gulf regions.

The dominant exposures of the overlying sediments of the Georgina Basin occur to the south and south-east of the Barkly Plain, where they form extensive low ranges which outline the broad folds formed during the Alice Springs Orogeny (ca. 350 Ma). The northern part of the basin was very shallow and quickly filled with the first influx of sediments, suggesting a subdued hinterland existed at the time. The Alice Springs Orogeny did not affect the northern part of the basin that coincides with the Barkly Plain - here the sequence has remained largely flat-lying (Smith, 1972). This absence of folding and uplift indicates that very little or no topographic variation subsequently formed.

The youngest hills or mountains that existed in the region were probably formed during the Neoproterozoic (ca. 1100 Ma) and in parts, particularly the east, during the Palaeoproterozoic (ca. 1800 Ma). Therefore the landscape of the Barkly Plain has been an area of subdued to flat topography for at least 500 million years and probably much longer.

· Ma = million years ago

#### THE RECENT PAST TO PRESENT

During the Tertiary (60 Ma - ca. 1 Ma) the area experienced tropical climatic confitions, as did much of the Australian continent. Widespread laterite profiles and detrital deposits developed in the largely peneplained landscape, probably strongly associated with the drainage and ground water regimes of the time. The lowest lying parts of the country held shallow freshwater to brackish lakes and swamps, and thin deposits of limestone accumulated in these areas (e.g. Brunette Limestone). It is interesting to note that this 25 million year old rock is the same age and was deposited in a similar environment to the famous Riversleigh Beds of western Queensland which contain the richest fauna assemblage of this age in Australia. Investigations to date have uncovered mostly scattered gastropods in the Brunette Limestone (Randal and Nicholls, 1963).

The deposits of Brunette Limestone largely coincide with the present day endoreisic drainage system, and the lateritic palaeoplains show only very slight elevation above the black soil plains. These observations indicate that the topographic configuration of the Barkly Plain has changed little since the Tertiary.

The very weak incision by present day drainage, the localised exposure of the Brunette Limestone, and the slowly receding lateritic palaeoplain provide evidence that minor rejuvenation of the landscape has occurred sometime since the deposition of the Limestone. Therefore the Barkly Plain probably contains greater topographic variation now than it has for the past 25 million years.

Historically the 'black soil' plains ('downs') have been described as Tertiary swamp deposits (Christian *et al.*, 1954; Randal and Nicholls, 1963) formed concurrently with the lateritic plain, or soils derived at least in part directly from the carbonate substrate (Randal, 1966; Grant, 1989). Our work suggests that this is not the case, and that the soils are largely derived through transformation and stripping of the lateritic palaeoplain. Alluvial soils are confined to areas of Tertiary and modern drainage and have distinctive characteristics.

#### THE IMPORTANCE OF BEING GILGAIED

The Barkly Plain comprises considerable expanses of gilgaied surfaces and observations over large areas show that their distribution is strongly landscape correlated. Generally they lie between the lateritic plains and the non-gilgaied downs country. These are the areas of greatest slope and therefore are the most dynamic part of the landscape. The relationship between landscape and gilgai is one of cause and effect, although not in the way that one might first imagine. Rather than gilgai forming in this part of the landscape, we believe gilgai are one of the major processes in forming this part of the landscape.

Although little is understood of the processes of gilgai formation, it is generally believed that the major mechanism involves the bringing of subsoil material to the surface (e.g. Hubble *et al.*, 1983; Leeper, 1967). The conditions recognised as essential for gilgai are the presence of swell-shrink clays (smectite) in the soil and a marked seasonality in rainfall, to allow differentiation of swelling and shrinking cycles.

Whilst climatic conditions are favourable on the Barkly Plain, smectite mostly occurs in the nongilgaied downs and alluvial country, and in gilgai on the margins of the lateritic palaeoplain. The investigation of deep soil pits on gilgaied lateritic rises clearly shows that subsurface material is not being brought to the surface in the gilgai. We believe that the formation of the gilgai is the result of conversion of the kaolinitic (non-swelling) clay soils of the lateritic palaeoplain to the smectite (swelling) soils of the gilgai and downs country. The process has been described by Veen (1972) in clay soils of south-east Queensland.

The kaolinite clays formed in the lateritic soils that covered the Barkly Plain during the Tertiary when the soil environment and climatic conditions were favourable. Climate and soil chemical environments are now quite different (e.g. the climate is much drier). Kaolinite is no longer stable in the soil system and chemical conditions are favourable to the formation of smectite. Some unknown mechanism initiates a conversion of kaolinite to smectite at a shallow subsurface level. This conversion entails a considerable volume increase, and as the reaction progresses stresses build up as the smectites swell and shrink with the seasons. The surface expression of this is the gilgai.

The lateritic plain has been and is continually modified as gilgai appear and expand. Very shallow slopes developed through weak drainage incision and the continuing activity of gilgai. This initiated erosion and the transport of material downslope into the drainage systems to form the alluvial soils. The gilgaied downs represent various stages of modification of the lateritic surface - from scattered gilgai on the lateritic shelf to dominantly downs soils with only weak gilgai depressions. The non-gilgai downs occur where the clay mineral transformation is complete and the soil is homogenised. The absence of a swelling differential in these soils precludes the development of gilgai.

In this way a landscape with very low topography, a senile drainage system, and very little run-off is none the less in a state of change. The rate of change can only be guessed at, but the above mentioned factors would indicate it is probably very slow indeed.

#### SOILS AND PASTURE

The variations in soil genesis and history are reflected in pasture distribution. An understanding of their interaction is seen as vital to appropriate land management in this region as it is one of the most productive cattle growing areas in the Northern Territory, producing about 25% of annual turn-off from less than 14% of total pastoral land (Cann, *pers. comm.*).

The downs soils (both gilgai and non-gilgai) and the alluvial soils carry two essentially different pasture types (first recognised by Grant [1989]) and it is important to recognise that this basic pasture dichotomy is the result of geomorphic processes and not a grazing effect.

We consider the downs soils to be strongly leached - they no longer contain any calcareous material either as coarse fragments or in the fine earth, except those associated with the Brunette Limestone which retain the calcareous characteristics of their source material. These soils predominantly support the mitchell grass pastures that characterise the Barkly Plain. Most of these mitchell grass pastures include a variable annual grass component.

The alluvial soils are largely derived from reworking of the downs soils with possibly the addition of some organic material. These alluvial soils support dominantly annual pastures of flinders grasses, spider grass, panicum, and bluebush, which provide the most nutritious feed resource of the area. Observations suggest that annual pastures (including the annual component of the mitchell grass pastures) are highly palatable and therefore favoured grazing, with the much more extensive feed resource of mitchell grass receiving lighter use by virtue of its moderate to poor palatability. However, the mitchell grass pastures are the mainstay of the pastoral industry because of their tolerance to the increasing grazing pressure through the dry season as the preferred annual pastures are depleted.

It is a commonly held belief that pastures dominated by annual grasses are an indication of pasture degradation. We have shown that many annual pastures are soil and landform specific and thus should be a focus of long term monitoring including exclosure. To properly determine whether there is a shift towards the annual component of perennial pastures under a range of grazing pressures also requires specific study. To date only one pasture dynamics study has occurred in the region (Foran and Bastin, 1984; Ford, 1992). This research indicated that rainfall and seasonal conditions have a much greater influence on pasture than grazing, and that carefully managed grazing can have a positive effect on mitchell grass pastures. Our observations of heavily utilised areas around watering points suggest that an increase in, to total invasion of, unpalatable forbs (e.g. Flavaria australicus) and undesirable perennial grasses (e.g. Chrysopogon fallax) is the trend. In the moderately utilised areas that constitute the bulk of the grasslands however this situation may not hold.

#### **CONCLUSIONS**

The Barkly Plain could easily be considered a monotonous and unchanging environment. A study of its geological, geomorphological and climatic history demonstrates that even areas that on a large scale have changed little over immense periods of time can be dynamic. The mechanisms of change are however substantially different. A resource study ignores the interplay and relationship of these historical factors at the risk of becoming a resource inventory only.

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# THE CASE FOR MULTIPLE USE RESERVES IN WOODY WEED COUNTRY

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# **ABSTRACT**

Serious ecological and social problems in woody weed country of western NSW have occurred for nearly a century. Many properties are unviable and this paper presents evidence suggesting that it is both economically and biologically unfeasible to attempt rehabilitation. Woody weed country cannot yield enduring benefit while landuse involves constant grazing. Multiple use reserves incorporating opportunistic grazing are proposed. Government has the role of ensuring that landuse reflects modern society's goal of conserving natural resource capital, especially on Crown land.

#### INTRODUCTION

Serious ecological and social problems have been reported in the semi-arid woodlands of western NSW since the turn of the century (Anon. 1901, Anon. 1969, Anon. 1983, Graham *et al.* 1989, Anon. 1992). Yet despite repeated calls to combat depleted productivity, social problems and more recently, species extinction, all these problems persist. This is unacceptable. Modern society is becoming increasingly aware of both the market and non market values associated with rangelands. It aspires towards a sustainably managed environment (Holmes 1994).

The Western Division currently faces a crisis which "is arguably the most serious since European settlement" (Anon. 1992). Problems are most severe in the "shrubbed-up" semi-arid woodlands of north western NSW and south western Qld. A significant number of pastoralists in this sort of country are simply no longer viable. In December 1993 mean debt burden of the 135 clients who used the Bourke Rural Counselling Service was greater than \$400,000 (Bourke Rural Counsellor, pers. comm.). Another round of intensive agency/community inquiries has ensued in a quest to find solutions to complex problems (viz, West 2000 in NSW, the South West Strategy of Qld and the National Strategy for Rangeland Management).

In this paper I offer a feasible resolution to the impasse which currently besets those who occupy woody weed country. I propose a change in landuse which involves; (1) accepting existing woody weed populations over broad areas (because we really have no choice), (2) enabling multi-sector community use, and (3) accommodating grazing, but only under appropriate seasonal conditions. To facilitate this, I envisage a tenure change from Crown Lease to Reserve for Multiple Use in certain cases. The proposal offers significant benefits but will require considerable shift in community thinking and strong commitment from government to come about.

# **WOODY WEED COUNTRY**

For present purposes "woody weed country" does not include all semi-arid woodlands. It includes woodlands on red earths (often calcareous) where windsheeting and watersheeting are significant and widespread. A large percentage of the ground surface is bare and there is little evidence of incorporated organic matter in the top soil layer. In comparison to stable red earths, Noble & Tongway (1986) found significantly less organic carbon, nitrogen and phosphate in the top 3 cm of sheet eroded soils.

Like a lot of grazed country, pasture biomass is meagre in dry times. What sets woody weed country apart is the observed failure of perennial pasture to respond significantly to rain, even during optimal seasonal conditions.

As the name implies, woody weed country is characterised by dense shrubs. Robson (unpubl.) has recorded *Eremophila, Dodonaea*, and *Senna* spp. densities of 7,000 stems/ha. In all but the rarest of good seasons, fire is precluded, even to those graziers who are willing and able to sacrifice production for shrub control. In any event, the high frequency and mature age structure of *Eremophila* populations significantly reduces the effectiveness of burning this country (Hodgkinson & Harrington 1985). Shrub reduction can now only be attempted using methods which are unaffordable over broad areas (see below).

#### THE FEASIBILITY OF REHABILITATING WOODY WEED COUNTRY

# **Economic feasibility**

Using the Condon (1968) procedure to estimate conservative grazing capacity I derived a rate of 1 dry sheep equivalent per 25ha in shrubbed up sandplain with a mean annual rainfall of 312 mm. Using 1993/94 gross margin estimates for wethers in the "scrubby western plains" of NSW (Ramsey & Bootle 1993) this equates to a gross margin for woody weed country of about \$0.16/ha. Even in 1989, a time of peak wool prices, the gross margin would still only have been \$0.95/ha.

The cost of chaining varies between \$6.00 and \$25.00/ha depending on vegetation type and method used. While it is the cheapest alternative available it is largely ineffective in much woody weed country where *E. sturtii* and *E. mitchellii* are common. Blade-ploughing is \$40.00 to \$85.00/ha. and chemical treatment in densities of 3,000 stems/ha would cost about \$270.00/ha.

Pastoralists clearly cannot afford even the initial phase of rehabilitation unless there is a guarantee that it results in a quantum increase in land productivity. Robson (1993) described an experiment in Bourke NSW which included blade-ploughed and totally exclosed treatments. The experiment had been running for nearly three years. About 1 tonne/ha of good pasture had regenerated in these treatments and in response to two successive good summers (each >200mm rain). Had stock been re-introduced the expected gross margin might have been \$0.90/ha (above method). The same pastures in 1989 might have returned \$5.25/ha.

The feasibility of just controlling shrubs is highly questionable even when country is returned to current full capacity and at the unsustainable wool prices of the late 1980's. I haven't yet accounted for the costs of wild herbivore control and de-stocking both of which are needed to restore productivity with any degree of certainty (Noble & Hodgkinson 1993, Robson 1993). Nor have I included follow-up shrub control (fire and/or chemical) or the option of sowing pasture seed. Many of the costs of rehabilitation are difficult to gauge because they are distributed sporadically over time. However it is reasonable to expect that collectively, they would equal the initial capital outlay.

The rationale for high cost rehabilitation programs in low productivity lands is fundamentally flawed. The problem is that pastoralists can't afford to manage land conservatively after having spent so much initially. Experience in the Bourke district indicates that managers re-introduce stock too hastily and heavily after shrub treatment (Robson unpubl.). This is predictable given the immense pressure exerted on pastoralists to recoup funds as quickly as possible. However, current practices seriously jeopardise the chances of long term improvement to productivity since they re-instate many of the influences which helped create the problem in the first place.

# **Biological feasibility**

Nobody has yet definitively explained the causes and processes of increased woodiness in arid lands. However, there has been a connection between shrub encroachment and settled pastoralism worldwide in the past 150 years. Ecologists now concur that encroachment is likely to be a syndrome involving variable weather patterns, overgrazing and fire suppression (Harrington *et al.* 1984). Local anomalies are common however and generalisations must be made with care.

Mayeux et al. (1992) postulate another reason which might partially explain the ubiquity of shrub encroachment in arid environments. They present evidence suggesting that increased atmospheric CO<sub>2</sub>, as a consequence of industrialisation, has significantly reduced the competitive advantage of C4 plants over C3 plants within the last 150 years. Growth rates, biomass and leaf area accumulation of C3 plants have all increased at greater rates than those of C4 plants in response to additional CO<sub>2</sub>. In general, broadleaved herbs, shrubs and trees utilise the C3 photosynthetic pathway while warmseason grasses are C4 plants. The hypothesis has profound implications for semi-arid woodlands in tropical and sub-tropical latitudes where warm-season grasses are predominantly C4 plants. The developments postulated appear to be consistent with observation and if this is the case, we have no choice but to accept the presence and increased vigour of woody plants.

The evidence above supports what has been demonstrable for some time; that rehabilitation in woody weed country is unviable. Individual managers have lost any realistic means by which to improve their prospects.

#### MULTIPLE USE RESERVES

# Elements of the proposal

The proposal would begin with the delineation of problem areas. The government would then create the provision for gradual and voluntary relinquishment of Crown Leases but only when lessees wished to sell. There would be no forced acquisition. Tenure would be changed to Reserve at point of transfer. All stock would be removed. Reserve workers would be appointed to maintain certain improvements, control unwanted plants and animals and co-ordinate activities by the various land users.

Kangaroos and goats would be controlled and harvested for sale. Commercial interests might stem from the managed use of non-grazed flora for bush foods, cabinet timbers and cut flowers. Recreation would also rank as an important landuse given the number of people now seeking access to undeveloped regions.

Technical guidelines would be developed to determine safe thresholds of pasture utilisation and to implement a system of tactical response management. After sufficient effective growing seasons stock owners would be given the opportunity to bid for grazing rights in a certain area for a set period.

This proposal is based on the "Network of Regional Reserves" suggested at a national workshop held in 1992 at Cobar NSW (Anon. 1993). Freudenberger (1993) describes a scenario with many functional similarities but envisages it applying to all rangelands.

#### Obstacles and benefits

Enthusiastic support by all sectors of society would be essential to give government the mandate for land management reform. Governments would only re-arrange finite budgets with strong public endorsement. Despite the appeal of the concept, acceptance is unlikely to be widespread, at least initially. European sentiment is strongly linked to the notion of exclusive occupancy and land ownership (even on Crown Lands). This bond has been nurtured for centuries and is embedded in our present rural lifestyle and tenure system. The transition to acceptance would be difficult and require sensitive management. Public consultation would be essential.

The costs of purchasing and managing reserves would be significant but not insurmountable. As an indication, the annual budget (\$2.5m) for land acquisition by NSW National Parks & Wildlife Service would have purchased all 13 shrubbed up properties (some 287,000 ha) transferred in the Bourke district within the last two years. If the mandate for this proposal ever reached the same level as it presently assumes for national parks, multiple use reserves would become a reality.

The cost of employing reserve workers would be offset by grazing fees, revenues raised from kangaroo and goat harvesting and royalties from other resources. Profit making principles could be applied to recreationists. The government would save the assistance presently being granted to struggling enterprises through schemes such as RAS, RAA, and primary producer sales tax exemptions.

In the short term the most tangible benefit would come from halting the current cycle of enterprise failure and associated human hardship. Property turnover is alarmingly frequent at present. While social adjustment might take time, individual lessee dislocation would be minimal since they would only leave when ready. Indeed, some might choose to take employment as reserve managers. Surrounding landholders would remain essentially undisturbed.

In the long run, we would all benefit from multiple use and the conservation of natural resource capital. There would be every reason to be confident about this given the potency of a system which would combine tactical response and concentrated land management by a person who is not encumbered with stock husbandry or commercial imperatives.

Governments have both the capacity and the responsibility to ensure that Crown land is used for the enduring benefit of society. This is not happening at present. The weight of problems in woody weed country render current advisory services and landcare initiatives largely ineffectual in real terms. Recent government proposals advocate significant reform yet remain superficial at the strategic level. Like previous initiatives they fail to address the fundamental mis-match between landuse and land capability. Multiple use reserves have the potential to do just this.

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# COSTING THE EFFECTS OF STOCKING DECISIONS IN AN UNCERTAIN ENVIRONMENT

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#### **ABSTRACT**

The influence of stocking strategy on the distributions of net returns (R/ha) in the semi-arid savanna of Natal, South Africa were examined using a spreadsheet-based bio-economic model (LOWBEEF). Increased stocking increased the risk of losses during drier seasons while lighter stocking was at the cost of higher returns during wetter seasons. A flexible approach may combine the advantages of each approach. The development of cumulative probability distributions may allow range users to assess the level of risk attached to different strategies. Incorporation of the ecological effects of stocking strategies as feedback into the model would be important to evaluate ecological risk.

# **INTRODUCTION**

Range managers in arid and semi-arid systems operate in a complex and uncertain environment where rainfall variability is a major determinant of system dynamics. The cost of overgrazing in arid and semi-arid environments may consequently be reflected by increased periods of supplementation, rather than by reduced livestock production, and by increased ecological risk associated with soil loss and woody plant encroachment. Evaluation of the risk associated with various stocking decisions is fundamental to the development of strategies which meet short-term economic objectives and minimise long-term ecological risk. This paper examines the risk and hence cost associated with stocking strategies for a beef enterprise in the semi-arid savanna of Natal, South Africa.

#### STUDY AREA

The semi-arid savanna or Lowveld of Natal occupies the broad coastal plain on the eastern seaboard of South Africa and comprises a herbaceous layer dominated by *Themeda triandra*, *Panicum maximum* and *P. coloratum*, and a woody layer characterised by *Acacia* species. Rainfall may vary considerably, both temporally and spatially and, while the mean annual rainfall ranges between 500 and 800 mm, seasons of less than 100 mm or over 1000 mm may occur. Cropping potential is consequently limited and extensive farming systems comprise beef, beef/game and game enterprises.

#### **PROCEDURE**

A bio-economic simulation model (**LOWBEEF**) (Hatch in prep.) was used to examine the influence of various cattle stocking strategies and range condition scores on net return (R/ha) under stochastic seasonal rainfall (measured 1 July to 30 June). An 800-year simulation was considered adequate to assess the risk attached to each strategy and cumulative probability distributions (CPD) were developed for each strategy.

Stocking strategies comprised five levels of set stocking (0.20, 0.25, 0.30, 0.35 and 0.40 large stock units/ha) and a climate-dependent strategy, where stocking rate was adjusted according to rainfall during the previous season.

Range condition was indexed as the sum of proportions of three key forage species; i.e. *Themeda triandra*, *Panicum maximum* and *P. coloratum*. Range scores of 10, 50, 80 and a dynamic score, based on a conceptual model where rainfall in the previous season influenced range composition in the subsequent season (Hatch in prep.), were examined.

#### **RESULTS**

Range condition played an important role in determining the risk of negative returns or losses (R/ha) (Fig. 1). For example, a range score of 10 implied a greater than 50% probability of incurring a loss irrespective of stocking strategy while, even for 'heavy' stocking (0.40 LSU/ha), a range score of 80 had a less than 30% chance of showing a loss. Increased stocking acted to influence the slope of the CPD and to increase the variability in returns. This enhanced the probability of both increased profits and losses for the static range (Fig. 1) and dynamic model (Fig. 2). Climate-dependent stocking reduced the risk of losses during drier seasons and increased the potential for higher returns during wetter seasons (Fig. 2).

#### **DISCUSSION**

Although the risk of financial loss was reduced with lighter stocking, this was at the opportunity cost of higher returns during wetter seasons. In contrast, increased stocking increased the probability of increased returns during wetter seasons at the cost of increased risk of forage deficits and highly negative returns during drier seasons. Importantly, ecological risk may increase as stocking is increased. A flexible or climate-dependent strategy, where stock numbers are adjusted according to the previous season's rainfall, may combine the benefits of each approach and reduce financial risk. Errors may carry high ecological costs, where for example a good season would increase stock numbers into a subsequent dry season and increase ecological risk. Although this may address short-term financial objectives, implicit in the development of sustainable strategies is the consideration of ecological risk. Incorporation of conceptual models of range dynamics would provide feedback into the system and indicate the ecological risk and economic costs associated with various strategies. Integration of dynamic range models which reflect interactions between rainfall and stocking rate and incorporate system thresholds may be an important means of assessing the risk of various strategies. The use of CPD derived from bio-economic models may provide an important extension tool to demonstrate the financial and ecological effects of different strategies.

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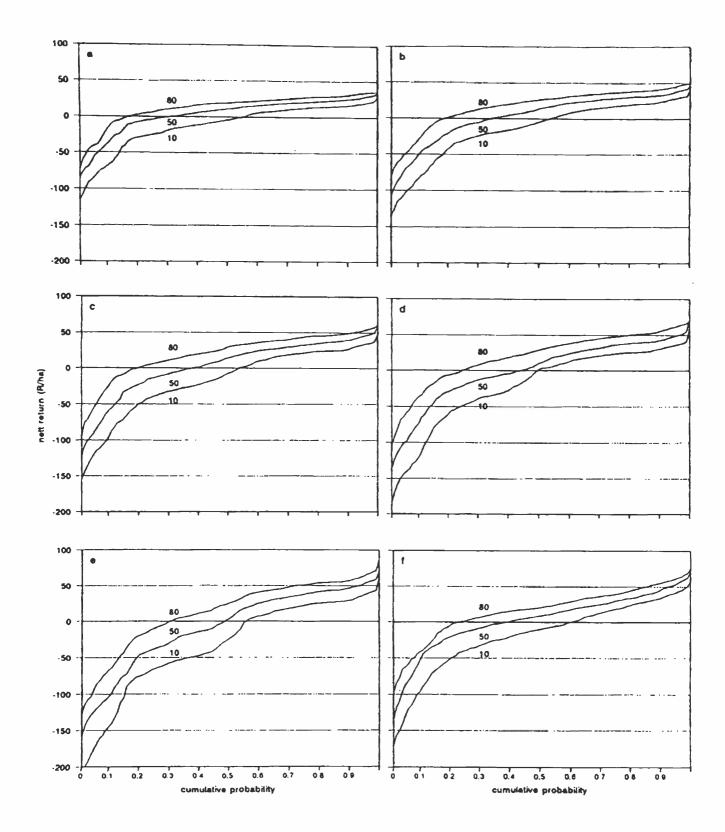


Fig. 1. The distribution of net returns (R/ha) for range condition scores (indexed as the sum of proportions of *Themeda triandra*, *Panicum maximum* and *P. coloratum*) of 10, 50 and 80, and stocking strategies of a) 0.20 LSU/ha, b) 0.25 LSU/ha, c) 0.30 LSU/ha, d) 0.35 LSU/ha, e) 0.40 LSU/ha and f) climate-dependent stocking.

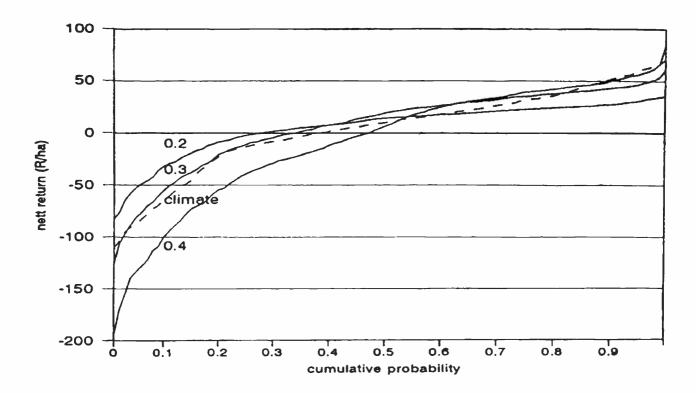


Fig. 2. The influence of stocking strategy (0.20, 0.30, 0.40 LSU/ha and a climate-dependent strategy) on the distribution of net returns (R/ha) with a dynamic range model.

# TOTAL RANCH MANAGEMENT STRATEGIC MANAGEMENT OF RANGE ECOSYSTEMS

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#### **ABSTRACT**

Ranching success depends on the ability of the land manager to select the right things to do and make appropriate adjustments as constraints and opportunities change. Ranchers are renewable resource ecosystem managers that operate as an organism within the ecosystem to control or manipulate resource flows for achieving the most important ranch goals including sustainability. Today these goals must also be compatible with consumer and societal goals often regulated through political mandates. Ranches are no longer individual "ecosystems". They are part of regional, national and the global ecosystem thus are influenced by the increasingly broader "environmental" factors.

Total ranch management emphasizes strategic management of all ranch resources to achieve the most important "ranch" goals. These goals must be specific, measurable, attainable, related, and trackable. Goals are developed for all resources at the strategic, tactical and operational levels of management. Decision-making is more important than technology used. Planning and management are proactive response-driven (i.e. needed responses versus achieved responses). In this way, monitoring can track and forecast implementation for timely adjustment with "adequate" evaluation of alternatives. Technology and tools are selected to effectively achieve needed responses. Past rancher training routinely concentrated on the "how to" of technology rather than the decision processes necessary for selecting the right things to do (White 1988). Crisis management changes to managing crisis situations - with proactive planning, implementation, control and adjustment, rather than hope on favourable rainfall, markets, government programs and an understanding banker, family and society.

Total Ranch Management (TRM) workshops have been conducted in Texas since 1985. This approach is being used in Oklahoma, Wyoming, Montana, Washington and California. A recent survey shows that "TRM training achieved its educational objectives and is a valuable program for ranchers and Extension employees" (White 1994).

# INTRODUCTION

Due to environmental factors, financial reasons, government regulations and mixed consumer demands and concerns, ranchers are increasingly faced with complex decisions and frequent crisis situations. "Ranchers today must redirect their management skills toward a total integrated resource management concept" (Troxel and White 1989). Just producing livestock products is not sufficient to sustain ranch resources, achieve needed profit levels and adequately address government and societal concerns and "needs". Total Ranch Management teaches an approach to better integrate and manage ranch resources for achieving ranch, family and societal goals within resource and environmental constraints. The planning and implementation of management decisions is a continual process with specifics unique to each ranch.

"A systematic approach is needed by most ranchers... to organize and analyze information to improve decisions" (White 1988). A strategic management planning process allows planning from long-term goal establishment to daily operations that better define the problems, assumptions, performance standards and selected alternatives for effective use of resources within sustainable use levels. "Strategic planning is the continuous process of making present... risk-taking decisions systematically and with the greatest knowledge of their futurity; organizing systematically the efforts needed to carry out these decisions; and measuring results of these decisions against the expectations through organized, systematic feedback... Systematic planning is necessary precisely because we cannot forecast" (Drucker 1974).

# TOTAL RANCH/ECOSYSTEM MANAGEMENT

Utilizing ecosystem principals when managing a ranch is important for understanding likely results and effects throughout the ecosystem(s). Ecosystems have been, and continue to be, influenced by human activities. The basic "principles" of human ecology helps a resource manager better understand and evaluate alternatives. Hardin (1984) identified 12 "principles":

- 1) we can never do merely one thing,
- 2) no effects are truly "side effects",
- 3) no system can long survive the effects of unopposed positive feedback,
- 4) negative feedback can be a positive boom,
- 5) thou shalt not transgress the carrying capacity,
- 6) the "sanctity of life" must give way before the "sanctity of the carrying capacity",
- 7) not all elements of the human carrying capacity are expansible
- 8) population growth ultimately makes democracy impossible,
- 9) selection dictates the direction of evaluation,
- 10) every biocide selects for its own failure,
- 11) every human law selects for its own evasion and
- 12) no inning is the last inning.

The first six principles have direct bearing to individual managers and their control on a ranch. These are used to influence resource flow and successional processes. In range ecosystems, harvestable production is in excess of that needed to sustain the resource with minimal outside inputs i.e. labour, livestock, physical facilities, capital and infrequent use of "agronomic" practices - i.e. herbicides, irrigation, brush clearing, seeding, fertilization. Natural ecological processes, plants, animals, soils and environmental constraints are operative. The basic management principle taught is how to balance resource use with harvestable supply to achieve best and highest ranch benefits, direct ranch change, and maintain diversity and flexibility to meet future consumer demands. Planning identifies needed responses and needed resources and these are compared to available and future resources. Adjustments are made after evaluating the "balance" and then the manager influences change in the desired direction; i.e. improve, maintain or deteriorate the resource.

# SELECTING THE RIGHT THINGS TO DO

What management achieves is more important than what is done or what technology or tools were used. "Rather than deciding what to do, a manager first identifies needed responses to achieve goals, then selects the most appropriate way to achieve those responses" (Troxel and White 1989). If responses are not achievable then goals will not be achieved and goals are not realistic. Strategic goals determine tactical solutions for use of resources which determine operational activities for accomplishing needed responses (Figure 1).



Figure 1. Decision tree for selecting the right things to do (White 1988).

"Once a realistic workable plan is developed, day-to-day operations use this plan to compare with current and forecast resource flows to select priority activities and evaluate alternatives" (White 1988). "What if" situations and alternative courses of action can be evaluated before crisis situations develop. "Completion dates are the most important part of any schedule; however, it is also wise to designate some mileposts along the way... Mileposts are created for convenient intervals through the year... In this way, a manager does not suddenly realize at the end of the year that he is only halfway toward achieving his objectives" (Fulmer 1974). The resource flow schedules identify monthly or quarterly performance standards (mileposts) for comparing the plan to actual and forecast conditions. Actual resource flows are periodically updated for comparison, "what if" scenarios and to provide a database for future planning. In the future such records may also be important documentation for justifying decisions before citizen and regulatory groups. In Texas, written prescribe-burn plans and actual records are recommended to "protect" the landowner against lawsuits claiming negligence when a fire escapes and damages someone else's property due to unpredicted events.

Selecting the right things to do, then doing them right is the key to success. Doing the wrong things well is an ineffective use of valuable resources. As range ecosystem managers, a diversity of benefits can be marketed and are desired by "consumers" - not just livestock products. The "environmental movement" is recognizing many of the benefits we produce in addition to food and fibre. They can be our greatest allies or our worst enemies. It depends on us showing good stewardship and selecting the right things to do that sustains the range ecosystem with minimal adverse impacts. The planning and management process can include these individuals, thus, improving their understanding of ecosystem management and support of your "risk taking" decisions.

Thresholds for resource sustainability and financial survival where livestock grazing is used are stressed for operational planning and decision making. Other resource-use efficiency ratios are used to improve planning and management; e.g. current assets:current liabilities, white-tail deer harvest:total population, livestock weight sold:livestock biomass. Stocking rate decisions based on forage surveys and rainfall monitoring are demonstrated to prevent drought crisis situations.

#### **VALUE OF TRM TRAINING**

A survey of 251 ranchers and 129 Extension Total Ranch Management participants was conducted in 1992. Participants better understand the ranch as a whole; establish goals; achieve financial, production, and range needs; and ranchers are more cost-conscience and have more confidence in making ranch decisions (White 1994). The majority of ranchers and Extension personnel had traditionalist management styles (55% and 70.3% respectively) (Meyers-Briggs). Ranchers are more visionary (18.1%) than Extension personnel (7.7%).

# **SUMMARY**

Success or failure depends on management. Management must make appropriate decisions that adjust to current and forecast conditions leading toward long-term strategic goal accomplishment. Today's ranchers are range ecosystem managers that may use livestock as a tactical solution for harvesting resources to convert to financial resources for sustaining the ranch and family. Ecological and business management principles are used in a strategic management process to develop realistic plans and control resource flows.

"The success of ranchers, researchers and Extension programs requires a total ranch approach without over-emphasis on specific components" (White 1988). Total Ranch Management training has successfully helped participants better understand the ranch as a whole, establish goals, and achieve financial, production and range needs. Their confidence in ranch decision-making was improved (chance of success). This type of program should have priority for training of ranchers and Extension employees.

Ranchers using a TRM planning and management process will improve with experience and more accurate analysis. "Use of a more systematic approach to organize and analyze information should reduce reliance on intuition" (White 1988) and hope. Only through the process of planning can ranchers decide whose advice is timely and adopt alternatives that best meet ranch and societal needs. TRM cannot insure success, but a rancher should be in better control of the ranch and its future.

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Note: Prof. Larry White was made a fellow of the Society for Range Management in 1994 and has received numerous other awards during a distinguished career. His primary interests are incorporating a Total Range Management perspective in ranch decision-making, understanding rancher decision-making, grazing management with emphasis on stocking rate decisions, and prescribed burning. His present studies include the analysis of "the human factor in Texas Range Resources Management", success of ranchers following Total Ranch Management training, threshold residue requirements for sustainable range resources, use of electronic ear-tags for fenceless grazing control, water quality following chemical brush control and rangeland environmental issues such as the Rangeland Environmental Issues Forum.

# LOCAL BEST PRACTICE, PARTICIPATORY PROBLEM SOLVING AND BENCHMARKING TO IMPROVE RANGELAND MANAGEMENT

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#### **ABSTRACT**

Motivation is an important contributing factor to decision-making. A strategy to enhance producer participation and ownership of processes to improve rangeland management is described. The strategy uses a process of Participatory Problem Solving, a method of working with small groups, and the use of targeted methods and techniques to maximise motivation and learning.

#### THE APPROACH

To improve the management of rangelands **change** has to occur. The outcomes of all rangelands Research, Development and Extension efforts should be to facilitate behaviour changes in rangeland managers. Effective learning strategies and processes are the key to achieve these changes. Processes need to:

- 1. **Motivate managers**. Adults are most likely to be motivated if they have 'ownership' of the process and active participation from the outset.
- 2. **Maximise the effectiveness of learning**. This can be achieved by designing and/or using appropriate learning processes, methods and techniques to address critical components of problem solving.
- 3. **Provide for evaluation of performance**. People are motivated by 'scoring goals'. Performance must be measured in order to make informed decisions about improving processes and results.

To develop strategies to achieve these goals is difficult because rangeland management systems are complex, and because many players are involved (researchers, extensionists, producer families, etc.). A fundamental problem standing in the way of learning in the rural environment is a lack of a universal definition of "extension". This absence of definition results in a poorly articulated theoretical basis for action (Russel et al. 1989). The concept of Technology Transfer' has contributed to processes which are 'technology-driven', rather than driven by sound principles of adult learning.

Kolb (1976) proposed a cycle of learning which has been universally adopted as a model for individual and group learning. Using Kolb's model we have developed a practical 'workable' strategy for achieving change in range management.

The strategy is based on:

- 1. A process of Participatory Problem Solving (PPS). Figure 1 shows the critical components for problem solving in rangeland management. All components need to be addressed to achieve behaviour change.
- 2. A method of using small groups in local areas. In previous publications (Clark et al. 1990; Clark & Filet 1992; Clark & Coffey 1993) we have used the term Local Consensus Data (LCD) to describe a technique of working with groups of producers in local areas. We now use the term Local Best Practice (Clark & Lawrence 1994). We want to emphasise learning rather than consensus, and we do not advocate using local groups to obtain data without benefit to the groups in the short-term.

Local Best Practice (LBP) groups are self-selected-teams of local producers. To maximise learning these groups need to be in the order of 6-8 people. In groups of this size people are more likely to contribute their knowledge and their ignorance! If groups are made aware of processes and roles which characterise highly effective groups they appear to function better (Likert 1984). To enhance learning, continuity of processes is important to provide for reflection and

conceptual abstraction (Kolb 1976). Shorter travel times in local areas facilitates continuity of group learning processes.

3. **The use of targeted methods, techniques and tools**. Table 1 lists a range of methods which can be selected and integrated to maximise learning at different stages in the problem solving process (Figure 1). Woods *et al.* (1993) review the efficacy of many of these methods.

### A PARTICIPATORY PROBLEM SOLVING CYCLE

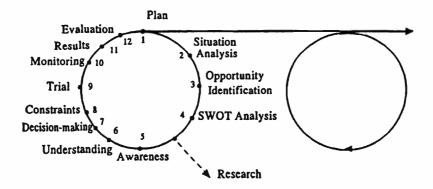


Figure 1. A model of critical components of problem solving in rangeland management (see also Woods *et al.* 1993).

### IMPLEMENTATION OF THE STRATEGY AND EXPERIENCE GAINED

The strategy was implemented by managing operations in 4 phases (Clark & Filet 1992).

# Phase 1 - Current best practices, problems, solutions and opportunities

# Plan

Our plan was to participate with producers, researchers and extensionists to contribute to the development of sustainable beef production systems in central Queensland. Our project was funded by the Meat Research Corporation (MRC) because of concern that a significant proportion of rangelands had suffered degradation and required improved management (Tothill & Gillies 1992). The plan involved the use of PPS together with LBP groups to:

- \* promote producer ownership
- \* describe current best practices for sustainable production and use these to identify opportunities for improved practices
- \* use a benchmarking approach

Benchmarking is used successfully in the manufacturing industries, but it is yet to be applied systematically to extensive grazing industries (Clark & Coffey 1993). Extension activities rarely plan to measure the achievement of outcomes against benchmarks.

# Situation analysis

In participation with producers, we established LBP groups in all the major pasture communities in central Queensland (Clark & Filet 1992). Project participants have developed a technique to utilise local knowledge and seperience to describe:

- \* current best management practices
- local problems and proposed solutions
- opportunities for improved practice

This LBP technique involved documenting the discussions of a 3 hour meeting and using the draft report as a focus for a second 3 hour meeting which culminated in a report of local best practice. Learning was facilitated by encouraging debate and reasoning. Ison & Humphreys (1993) state that 'ownership' by the LBP groups of the documents (and the identified practices and problems) was high.

# Phase 2 - Opportunities for improved practice

# Problem and opportunity identification

A process was designed to enhance creativity in problem and opportunity identification. This process was to challenge specialists (researchers, extensionists and other service agents) to focus on the descriptions (reports) of current best practice, and identify and develop opportunities to improve practices and set new benchmarks for best practices. Workshops and small group activities (Table 1) were held with local producers to ensure awareness, understanding and participation in the further development of opportunities.

# Swot analysis

The use of this technique is highlighted at this stage because it helps in the process of prioritising opportunities for resource allocation.

# Phase 3 - Decision-making for change

# Awareness of opportunities

"You don't know what you don't know". It is important to create awareness of new opportunities (Table 1). However awareness does not necessarily mean understanding. They are two very different components of the PPS cycle. For complex problems it is important that the PPS cycle is not broken at this point with a return to an earlier stage.

# Understanding of opportunities

Often the success of traditional extension exercises is measured by 'the number of chairs occupied'. Participants in learning exercises will not contribute their ignorance if the environment is threatening (in large groups), consequently they don't ask questions! Ensuring understanding has been the most neglected component of processes designed to resolve complex problems. Techniques need to be used to ensure this happens (Table 1).

### Decision-making

Motivation is an important contributing factor to decision-making. Small group activities offering peer support can contribute to such motivation. Goal setting and motivational activities to focus on goal achievement will help. Decision support aids (decision trees, risk analyses, etc.) can facilitate decision-making. Critical steps to decision-making need to be fulfilled (Norton & Mumford 1993).

# Dealing with constraints

Major on-farm constraints are usually time and money. Attitudes, lifestyle aspirations and other sociological concerns must also be addressed. Off-farm issues of policy, markets and other sociopolitical concerns may limit behaviour changes (Clark *et al.* 1992; Clark 1993). Techniques to deal with these issues need to be developed (Table 1; Clark & Coffey 1993).

# Phase 4 - Implementation and evaluation of new practices

### Trial

Trials need to be relevant to individuals but for the industry's benefit they should also contribute to group learning. Such relevance has been well demonstrated by the "Producer Demonstration Site" program in northern Australia, although greater use of the PPS cycle may enhance its outcomes. Processes designed to network the activities and results of similar or related trials will result in 'multiplying' the learning from all trials.

# **Monitoring**

The use of Standard Performance Assessments (SPA's - Table 2) enhances the comparison and dissemination of results from the trials. They also become key measures of any progress in improving the sustainability of a production system (Clark & Coffey 1993).

Table 2. Standardised Performance Assessments for Central Queensland beef enterprises.

1.	Rainfall
2.	Stocking rate (animal equivalents)
3.	Cows pregnant/100 cows exposed to bulls
4.	Calves branded/100 cows exposed
5.	Calves weaned/100 cows exposed to bulls
6.	Mean weaning weight/age (days)
7.	Kilograms weaned/100 cows exposed to bulls
8.	Liveweight sold/hectare
9.	Liveweight sold/breeder
10.	Liveweight sold/AE
11.	Operating costs and/or profit/hectare
12.	Operating costs and/or profit/breeder
13.	Operating costs and/or profit/AE
14.	'Grass Check' monitoring process

### Results

Results from trials enable an objective evaluation of changes in management. The dissemination and understanding of these results can provide a powerful 'multiplier' technique for the motivation of other producers.

### **Evaluation**

The effectiveness of learning is enhanced by the processes of reflection and evaluation. Action learning processes should be applied at all steps of the PPS cycle. These processes will improve plans to do things better. Standard Performance Assessments provide data on which to base the setting of new benchmarks. The use of systematic bench-marking is probably the best technique to maximise gain toward achieving outcomes. To achieve a new benchmark, a new plan and new PPS cycle is initiated. Each PPS method and technique requires objective evaluation of its affectivity in achieving outcomes (Table 1). Evaluation can be enhanced by systematic action research processes.

### **OVERVIEW AND CONCLUSIONS**

# Key features

Learning principles are the basis of the PPS approach to improving rangeland management. The PPS cycle in combination with the LBP technique enables a range of methods and techniques (Table 1) to be selected and integrated to address critical components of PPS. This approach should enable the development of more effective learning processes and techniques.

# Strengths

The first phase of the strategy has motivated rangeland managers and received their support (Ison & Humphreys 1993). The high degree of end-user participation is likely to ensure the ability of each subsequent phase to build on the success of the previous phase.

### Weaknesses

The tendency to use producer-generated data to serve purposes other than those for which the participants have enthusiasm for is a major weakness. This can discredit the process and result in the evaporation of the motivation necessary to drive the PPS cycle.

### **Pitfalls**

Small groups are acknowledged to enhance learning processes (Joyce *et al.* 1992). Associated with the formation of any group is a problem of those people excluded. This problem of perceived 'elitism' can be largely overcome by explaining the basis of using small groups and by encouraging the

formation of other LBP groups. The involvement of more producers is an option once the initial 'situation analysis' is complete. Good facilitation skills are critical to the success of PPS. A major pitfall is the tendency to address only some (not all) components of the PPS cycle.

# **ACKNOWLEDGMENTS**

Numerous producers have contributed to the development of the processes; their creativity and intuition is acknowledged. Many colleagues, particularly those involved with operations of the Sustainable Beef Production Systems Project have also contributed to the development of the strategy.

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Table 1. A matrix which can be used to help identify the most effective methods and techniques of achieving learning at critical components of the problem solving cycle. The scores, under each component, are a subjective assessment of the efficacy of each method. The scores are whole numbers between 1 and 5, 5 being the most effective (see also Woods *et al.* 1993).

METHODS					CRITICAL	CRITICAL COMPONENTS OF TH	TS OF TH	E PROBLEM SOLVING PROCESS	A SOLVING	PROCESS			
	Preparing a Plan	Doing a Situation	Identifying Problems/	Doing a SWOT	Creating Awareness	Creating Facilitating Awareness Understanding	Motivating Decision-	Addressing I Constraints	Addressing Implementing Constraints Trials	Doing Monitoring	Dissem- inating	Conducting Evaluation	
		Report	Opportunities	Analysis			making			SPA's	Results		
Small Groups	51	51	51	OI.	4	51	CI	O1	O1	O1	5	57	$\perp$
Workshops	4	4	4	4	4	4	4	2	2	4	4	ω	
Conferences	ယ	ω	ယ	2	ယ	ယ	ω	2	1	ဒ	ယ	2	
Property		ω	ယ	2	ь	22	ω	ω	ΟΊ	Ω	4	4	
Demonstrations													
Field Days	•	2	2	-	4	သ	2	12	4	4	ហ	ယ	
On-farm		4	4	အ	2	ω	ယ	ω	4	σι	ω	4	
Monitoring													
Comparative	ı	4	4	ယ	2	အ	ယ	ယ	4	4	4	4	
Financial													
Analysis													
Computer	2	4	4	4	ı	ယ	2	2	2	2	1	2	
Models													
Television	,	•	1	•	<b>σ</b> ι	2	2	1	1	1	ω	ω	
Radio		•	ı	•	4	2	ы	1	1	1	2	2	
Newspapers			1		4	2	2	1	_	1	2	2	
Newsletters		•	Ī		4	ω	.29	1	1	1	ω	ယ	
Video	1	ı	1	•	4	ယ	ယ	1	_	1	ω	ω	
Databases		2	2	_	-	1	1	•	•	1	_	_	
Sample		4	4	4	2	2	1	ယ	1	1		4	
Interviews													
Mailout	ı	ω	ယ	ယ	_	1	1	2	ı	1		ယ	
Surveys													
Telephone		ယ	ω	ယ	1	1	1	2		1	ı	ယ	
Surveys													
SPA's = Stance	dard Perfo	ormance F	Standard Performance Assessments										

# ARID ZONE RESOURCE PLANNING IN THE CORPORATE WORLD

Greg Campbell

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# **ABSTRACT**

Property management planning is a useful mechanism for appraising and integrating into pastoral practice, an increasing range of competing user demands. Careful planning enabled S. Kidman & Co. to develop a mechanism for integrating conservation with grazing on the Innamincka Regional Reserve in South Australia. Managing more than 10,000 cattle, 30,000 visitors, and the conservation of wetlands, requires substantial new infrastructure. Over 1,000 km² of seasonally flooded country was identified for more careful grazing management. A proposal to share the costs of new infrastructure was put to the South Australian government, along with a request for greater security of grazing rights. A good working relationship has been forged between the resource management agency and the grazing lessee.

# INTRODUCTION

S. Kidman & Co is Australia's fourth largest pastoral company and remains private and family owned. Kidmans run 130,000 cattle on 120,104 km² of pastoral lease and hold another 3,460 km² for wool growing. Over 94% of this leased area receives less than 250mm of annual rainfall. Kidmans have a proven, 100 year history as arid zone graziers.

Today's largely urbanised population is increasingly seeking recreation in the outback. The ready availability of 4WD vehicles and the community's desire to have an empathy with "the bush" places unprecedented pressures upon pastoralists. People on holidays in the outback seek access to a diverse range of sites and places. The conservation lobby increasingly regards pastoral leases as public conservation areas, and there is a community trend towards heritage listing and preserving any built or natural oddity in the landscape.

Within South Australian rangelands diamond hunting and petroleum exploration are at record intensity and this has both costs and benefits for the pastoral industry.

Kidmans regard Property Management Planning (PMP) as the appropriate mechanism for appraising and integrating into their management, these competing demands upon the rangelands. Recreation and tourism may also offer longer term investment opportunities and PMP is a suitable process for exploring and developing these in conjunction with the company's principal activity, pastoralism.

The planning process also has the requirement to analyse and recommend ways of improving and monitoring herd productivity, range condition, and financial performance.

In this paper Innamincka Station is used as a case study to indicate how PMP has paved the way for integrating conservation and grazing.

# BACKGROUND ON INNAMINCKA

Innamincka is a  $13,818~\rm km^2$  pastoral lease in the far north-east of South Australia. The  $110~\rm year$  average annual rainfall is  $173\rm mm$  which has an 80.7% variability. There is no formal growing season and 29% of years are drought years (receiving <75mm summer rain and <50mm winter rain). The wettest year was  $1974~\rm with~867mm$  and  $1940~\rm the$  driest with just  $13\rm mm$  of rain.

The property encompasses Cooper Creek and the variable wetlands known as the Coopei Lakes. A significant flood occurs in the Cooper in 50% of years.

The cattle herd has averaged more than 10,000 head over the last 50 years with the herd varying from highs of 20,000 head, to zero during the Brucellosis and Tuberculosis Eradication Campaign.

On Innamincka SANTOS has numerous well sites and substantial infrastructure associated with the extraction of natural gas. This gas is piped to Brisbane, Sydney and Adelaide for industrial and domestic use.

Over 30,000 tourists visit Innamincka each year, mainly during Easter and school holidays. The most popular activities are fishing, camping, bird watching, and exploring the graves and historic sites associated with the epic of Burke and Wills. Formal visitor surveys (Neumann and Freeth, 1987) indicated that 81% of visitors arrived in a 4WD vehicle, 87% did not want formal campgrounds and 70% desired unrestricted access to all parts of the property.

The waterholes and lakes provide a diversity of aquatic habitats from salt to fresh and permanent to ephemeral. They are the principal focus of the South Australian conservation lobby's ambitions for a world heritage listing for the region. These wetlands were in 1987, listed under the RAMSAR convention for the protection of wetlands of international significance for migratory birds. The wetland margins, river frontages, and the more extensive land types are subject to an intensive rangeland monitoring program by the South Australian Department of Environment and Natural Resources (DENR).

In 1988 the property was declared a Regional Reserve under the South Australian National Parks and Wildlife Act. This classification permits commercial land use but concessions to conservation are required in designated areas.

# **IDENTIFYING THE CONSERVATION PRIORITIES**

How closely does sustainable pastoralism meet the needs for sustainable ecosystems? How are the negative effects of too many rabbits and too many visitors accommodated within the drive for ecologically sustainable land management? Which parts of the landscape require most protection and during which seasons? A pastoralist today must come to grips with many of these questions and a multitude of buzz words and poorly defined community expectations. The technical information identifying the requirements of individual species or areas of land is insufficient for good management.

Some useful information was however, available for the Innamincka region. In our planning we used information from the biological inventory of the Coongie Lakes (Reid and Gillen, 1988) and the detailed rangeland monitoring reports (LAB, 1986; Tothill *et al.* 1991). General guidance was also given in the management plan for the Regional Reserve.

In summary, these studies did not identify any species exclusively dependant on the Coongie Lakes nor any which were absolutely tied to these lakes for some part of a season or their life cycle. Information on population dynamics and how these are linked to the variable hydrology of the region is sadly lacking. The RAMSAR listed wetlands at Innamincka are contained in a crudely positioned 20,000 km² triangle. The South Australian Conservation Council argues that the lower Cooper is a system "quite unrivalled elsewhere in the world" (CCSA, 1992) and that its prime value is its variability. Such generalised definitions of worth and conservation priority are difficult to address in a planning sense.

Despite a lack of cohesive prioritisation of conservation requirements, there are certain areas with obvious needs. Needs great enough to require a primary producer to take action - both to protect the productivity of the forage base and to protect against public criticisms of mismanagement. Cattle, tourists, and wildlife are heavily focussed on wetland margins and the more permanent freshwater wetlands in an arid environment are an obvious conservation priority (Morton *et al.*, in press). Reducing livestock pressure on the margins of the near-permanent freshwater wetlands is undoubtedly the highest conservation priority at Innamincka.

# **IDENTIFYING THE CONSERVATION COSTS**

For grazing and conservation to co-exist, fencing which permits the seasonal (drought or school holidays) exclusion of cattle from lakes and waterholes must be accompanied by the provision of alternative waters. In this way neighbouring, more drought resilient pastures can still be grazed. To clarify the infrastructure requirements Kidmans produced an intensive land system map of the reserve with the boundaries and extent of wetland and river frontage areas clearly shown in relation to existing infrastructure. We then marked on an overlay the additional fencing and waters required to enable spelling of the areas with the highest recreational use and/or conservation priority. These improvements included 145 km of fencing, four dams, one bore and two pumping systems on permanent waterholes. These were costed at \$489,000.

There was also a need to determine the costs of lost production. Carrying capacities were estimated to be 12 head per km² for the post-flood periods in the areas targeted for seasonal livestock exclusion. These areas cover approximately 1,050 km². Company records showed the gross margin for Innamincka cattle to be \$18.17 per beast per year (Note: all vehicle and fuel costs and all costs associated with labour were considered as variable costs in this calculation). Annual costs in lost production could then be determined given a few reasonable assumptions.

- All Cooper floods above 5.0 metres at the Innamincka gauging station were assumed to produce abundant ephemeral pastures on river frontages and adjacent flooded areas.
- These pastures were considered to provide at least six months valuable grazing at stocking rates of 12 head per km².
- Reducing the period of grazing to four months should leave adequate cover levels to meet most conservation objectives.

The lost grazing value would then be:

 $(2 \text{ months x } 12 \text{ head/km}^2 \text{ x } 1050 \text{ km}^2) / 12 \text{ x } $18.17 = $38,157 \text{ per flood year.}$ 

Since records show a flood above 5.0 metres occurs in 50% of years, the annual lost production to meet conservation objectives is approximately \$19,000.

The total cost of implementing these wetland conservation initiatives is beyond what would be considered economic in pastoral terms, although there are significant elements of the required infrastructure which would be beneficial for livestock and pasture management.

### SHARING THE COSTS WITH THE COMMUNITY

The next phase of planning identified that infrastructure which was sensible and realistic for livestock and pasture management. This included 94 km of fencing, two dams and two pumping systems on permanent waterholes. The other 51 km of fencing would be necessary to meet conservation rather than pastoral objectives. This latter fencing would also exclude stock from some permanent waters and would therefore need supporting by two dams and one bore. Costs of infrastructure for good pastoral land management were \$298,000, and those required to meet higher conservation goals were an additional \$191,000. Given the net community benefit in the substantial exclusion of livestock from wetlands popular for recreation, and the improvements in the conservation of cover levels and the integrity of channel banks and lake foreshores, it seemed reasonable to approach the South Australian Government for the \$191,000 worth of improvements targeting conservation. Upon holding a meeting with senior staff within DENR it was promising to learn that they had independently considered a similar approach and had in fact made an application to the new Liberal government for a policy determination on their willingness to fund such works. The DENR offered the services of an experienced rangeland ecologist to review the Kidman planning and recommend any necessary or useful modifications. We had however, a fully costed works program to put to Kidman management and the SA government.

# **CORPORATE CONCERNS**

As a pastoral company with extensive arid zone interests Kidmans were careful to ensure that significant areas were not allocated to total livestock exclusion. This would establish an unworkable and unpopular (within pastoral circles) precedent for conservation elsewhere within pastoral country. The company's preferred option within areas fenced for higher conservation would be a controlled grazing regime for the fattening of pre-sale stock. It would be essential that these areas have more intensive monitoring of the effects of livestock so that numbers and periods of grazing could be modified according to feedback. This could enable the costs of lost production to be partially recouped during periods of good local rainfall, perhaps in the absence of major flooding. The monitoring should also address vehicle and camping impact within smaller (1.0 km²) reference areas where grazing was excluded.

Kidmans also required an improved guarantee on their security of tenure and operating conditions, both of which had been threatened by the unpredictable consequences of a potential world heritage listing for the area. The guarantee would be sought as a statement that no higher form of conservation status would be imposed on fenced areas, the whole lease remaining as a Regional Reserve. The guarantee should also include a commitment that the SA Government would oppose a World Heritage listing for any portion of the Regional Reserve and would seek to convince the Federal Department of Environment that current planning and management, and the Regional Reserve structure, were establishing a model precedent for integrating pastoralism, tourism and conservation.

# BEYOND THE PLANNING

At the point of writing, the SA Government is considering the application for funds to assist with fencing areas of high conservation priority, as well as the Kidman request for an improved guarantee in business security. The outlook is hopeful as the new Liberal Government has pledged \$1.0M to be spent over two years on conservation initiatives within the arc of the mound springs and the Coongie Lakes region.

From the corporate point of view, the continuing high prices for beef provide the first real opportunity for some time to finance new property infrastructure, particularly where improvements in livestock and land management can be identified.

Careful planning and a brave commitment to the future may yet establish a new partnership way of doing business between a resource management agency and a grazing lessee.

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# A PRACTICAL APPROACH TO SELF ASSESSMENT AS PART OF A NATIONAL RESOURCE MONITORING STRATEGY

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### **ABSTRACT**

Management of arid-land resources is at a cross roads. The urban public voices increasing concerns about the sustainability of land use practices. Governments reduce resources available for arid land management as part of budget austerity measures. Arid-land users - pastoral, tourism and mining enterprises - must make a choice. They can do nothing and hope that the problem resolves itself, or they can tackle the problem themselves and control the direction of change.

Arid land users already monitor many things and there is an opportunity for them to develop monitoring systems for self-regulation of arid lands. Using simple techniques to monitor indicators of interest to them, land users - a qualified and experienced resource for arid land monitoring - are able to record resource trend and condition, as well as management and productivity information.

By monitoring their own resource base, land users increase the opportunity for self-regulation. If they collect information in a standardised way, they also contribute a large pool of resource information which can be collated to identify and rank problems for allocation of scarce human and financial resources to arid-land management, research and development.

### INTRODUCTION

The public is increasingly concerned about the impact of mining, tourism, and pastoralism on aridlands. They are also aware that the economic benefits of mining and tourism enterprises are significantly greater than the returns from arid-land pastoralism. For example the value of mine production in the arid sheep rangelands is more than twice the gross value of wool production from the same area (Beale *et al.*, 1990). Similarly, the gross value of mining production in northern Australia exceeds pastoral and tourism income by an order of magnitude (Young 1984).

Conservation groups and the mining industry actively promote the relative impacts of mining and pastoralism. Of the three economic land uses in arid Australia, pastoral land use has by far the most profound impact on the land. The public - voters and ultimate owners of Crown Land - increasingly put pressure on Governments to regulate and manage natural resources for the benefit of all. Pastoralists therefore have an incentive to demonstrate that they have a commitment to sustainable resource management.

Arid-lands are increasingly being managed as a multiple-use resource and regulators are charged with maintaining arid-land resources for "future needs" without knowing what those needs might be.

Governments manage increasing demands for public funds in an environment of fiscal restraint. Industry groups are encouraged to relieve pressure on government by adopting self-regulation and embracing privatisation of some services. Industries which rely on public resources - including Crown Land - and do not move towards self-regulation face the real danger of being over-regulated by Governments responding to pressure from a concerned public. Because of human and financial resource constraints, this regulation is likely to be unfriendly and paid for by resource users - the polluter pays principle.

Management of arid-land resources is therefore at a cross roads. Arid-land users - pastoral, tourism and mining enterprises - must make a choice. They can do nothing and hope that the problem resolves itself, or they can tackle the problem themselves and control the direction of change. Arid-land users have two strong incentives to adopt monitoring strategies for self-regulation - (i) if they do not, the public will demand that Governments monitor and manage arid-lands, the cost of which will be met by the arid-land users; and (ii) if they do not, monitoring will be designed to meet the needs of regulators rather than producers - weakening the linkage between monitoring and management.

### INDICATORS OF INTEREST TO LAND USERS

Working with pastoralists to identify indicators and develop monitoring systems helps overcome two flaws in arid-land resource management: (i) the lack of feedback from resource condition to economic status; and (ii) the emphasis placed on immediate animal productivity (Burnside and Faithfull, 1993). Under current monitoring techniques socio-economic and biological systems are uncoupled so that financial demands placed on resources do not respond to their immediate ability to produce (Harrington et al., 1984). Many pastoralists monitor the quantity and quality of their animals rather than their plant and soil resources, because livestock pay the bills. Animal condition is a poor measure of the state of the resource.

Pastoralists' requirements from monitoring are usually productivity based - to provide information which maximises production and minimises impact on rangeland resources. Pastoralists are interested in monitoring indicators which measure the effect of their management on the resource and which lead to maintained - or improved - resource productivity. Monitoring is of interest to resource users when it provides information to answer questions such as: Can my rangeland carry my livestock for another year without reducing profitability? or Is there any long term change that may be reducing the productivity and/or stability of my rangeland?

AACM's experience is that when indicators are selected with pastoralists, and monitoring systems are developed by them to meet their needs, pastoralists become actively involved in plant and soil resource monitoring. This approach strengthens the linkage between management, resource condition, and profitability. It also addresses the very important question of how pastoralists use information from monitoring range trend indicators to formulate management decisions (Burnside, 1990, 1992).

The following points have been identified by pastoralists as being important for a monitoring system (Nicolson, 1993):

- \* Indicators should vary with the requirements and conditions in each district.
- \* The system should be "user" friendly with a photo-point, simple transect, step pointing and photographic standards for biomass yield.
- \* The system should take no more than one hour to implement.
- \* Monitoring should correlate results and rangeland rating with a regional average to enable resource users to compare different management strategies and the impact they have on range condition and long term profitability. This also creates peer group incentives for adoption of resource management strategies.
- \* Monitoring data should be meaningful and be capable of correlation to animal health and production.
- \* The system should incorporate prescribed standards linking recommended maximum stocking rates with range condition at a particular time of year.
- \* Monitoring should also develop plant identification skills to strengthen the linkage between ecology and economics and improve the "lexicon" of indicator species which resource managers can read and use when monitoring their resource base.

# A SELF-MONITORING STRATEGY FOR PASTORALISTS

Based on 25 years international experience in participatory rangeland management, AACM International is working with pastoralists to develop self regulation strategies for chenopod rangelands and grasslands in Australia. The work is supported by the National Landcare Program. Our strategy recognises that insufficient resources have been allocated to showing how landcare reduces risk and increases sustainable income from arid-lands.

Pastoralists measure and record many things - for example stock numbers, rainfall, wool production, turnoff rates and the bank balance. It is becoming increasingly apparent that pastoralists are also interested to measure changes in the condition of resources they use.

Working with AACM's range resource monitoring team, pastoralists using chenopod shrublands and arid grasslands have developed a monitoring system to meet their needs. The key elements of both systems are:

Site Selection Most productive area; 0.75 to 3.5 km from the watering point (depending

on salinity); representative land type, more than 100 m from a fence,

track or other disturbed area.

**Photopoint** 20 m photopoint - established in each paddock with two star pickets

and two marker pegs graduated every 10 cm. Used at the same time each year, consistent with neighbouring resource users so that information can be shared and management impact on condition and

trend compared.

**Species Composition** Use of Jessup Transect (for Chenopod shrublands) and photographic

standards (for grasslands). This also provides a general indication of

biomass.

Management Record Recording stocking rate for sheep (as small stock unit days and ha/

SSU) or cattle (as large animal equivalents and km²/LAE).

Landscape Reading Landscape attributes to note in photopoint records including (i)

changes in woody weeds; (ii) change in the size of chenopod shrubs; (iii) new perennial plants; (iv) plant deaths; (v) density and vigour of perennial grass butts or plants between perennial bushes; and (vi)

proportion of desirable palatable versus undesirable grasses.

Information is recorded on a simple A4 sheet for each monitoring site. The record is kept by the resource user. Groups of users from similar areas compare their monitoring results at least once each year. In South Australia this is conveniently done with Soil Boards and Landcare Groups.

The monitoring systems described here have been reviewed by more than 50 pastoralists in seven "pastoral" soil boards - Central Flinders, Gawler Ranges, Kingoonya, Marla-Oodnadatta, Marree, North East Pastoral, and Northern Flinders Ranges. Twelve pastoralists are actively trialling the monitoring system on their leases at the moment before finalising the system for widespread adoption in late 1994.

The combination of objective and subjective data helps make the determination of range trend clear and unambiguous whilst at the same time enabling resource users to record their assessment of change based on their reading of the landscape. This combination enables resource users to use their judgement to link range trend and range management (Burnside and Faithfull, 1993). Combining quantitative and qualitative data also contributes to data resources used by regulatory authorities. The combination is especially appropriate for monitoring ecosystems under a state-and-transition model (Westoby *et al.*, 1989).

Technical specialists from the public and private sector have an important role in self-monitoring systems - not as regulators but as a skill resource to develop the capability and consistency of resource users for monitoring resource condition and trend. Resource users who adopt self-monitoring systems provide resource information which can be pooled with data from neighbouring resource users for collective analysis, as well as contributing to the national assessment of the state of the environment. This change in relationship between technical regulators and users is important for both parties, and sets a foundation for collaborative management of arid land resources in a multiple-use environment.

# A SELF-MONITORING STRATEGY FOR AUSTRALIA

By monitoring their own resources, arid-land users increase the opportunity for self regulation and the quantity of resource assessment data. This creates the opportunity for a national resource database which can be used to identify and prioritise problems for allocation of scarce human and financial resources to arid-land management, research and development.

The Australian State of the Environment (SoE) Reporting System is being developed on the basis of the "pressure-state-response" model advocated by the OECD. It makes extensive use of environmental indicators which measure trends in the condition of Australia's environment (SoE Reporting Unit, 1994).

If the SoE Reporting System is to be meaningful to resource users, it must record information from indicators selected and monitored by resource users wherever possible. This approach not only develops strong ownership of the information but reduces the cost of monitoring natural resource indicators - potentially increasing the quantity of data available for incorporation into the geographical information system/relational database management system (GIS/RDMS) being developed for the SoE Reporting System.

Self-monitoring may be less accurate than quantitative monitoring at a detailed or semi-detailed level. However, with training and experience, resource users have the ability to combine quantitative and qualitative data to make accurate and consistent judgements about resource condition and trend. Australia's arid-lands are so large and so sparsely inhabited that monitoring resource condition is uneconomic and unreliable if the resource users do not participate in every way. Not only are arid-land resource users the most cost effective monitoring resource, they are also the most effective means of linking indicators of condition and trend with resource management practices. Linkages between management and resource resilience/productivity are best judged by resource managers, with support from skilled technicians, since this reduces the barriers to adopting management strategies from lessons learned.

If the SoE Reporting System is able to collate monitoring data from more than 40 percent of arid-land resource users, it will have a valuable database from which to identify resource management priorities. This information would enable human and financial resources to be allocated to arid-land management, rehabilitation and research, in a planned way.

In this way, self-monitoring is integral to national participatory resource management by increasing the role of resource users in natural resource decision making. It is a model which is equally relevant to the management of other Australian resources. The information collected in this way is ultimately useful for national resource accounting systems (Repetto, 1989). Thus self-monitoring systems form the foundation for sustainable resource management at an enterprise, regional and national level.

Because of the widespread importance of self-monitoring for national resource management, the National Landcare Program and AACM International, have also initiated pilot programs for self monitoring acid soils, wind and sheet erosion, and soil structure decline. This work is being conducted with resource user groups in NSW, Victoria and South Australia. Using simple and replicable assessment techniques to monitor indicators of interest to land users - the pilot program forms part of a broader national resource monitoring strategy.

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### A RANGELANDS PERSPECTIVE IN SCHOOL EDUCATION

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### **ABSTRACT**

It is widely accepted that school education provides basic knowledge for future adult community members. Information and activities designed to teach school students about Australia's rangelands have always been in short supply. This is one factor which has led to a lack of knowledge in the general community about the physical, economic and social characteristics of a good three-fifths of this continent.

In NSW, recent developments and changes in the school education system have provided an opportunity for people involved with rangeland management to provide innovative and effective school education resource material. This can potentially emulsify some of the congealed fat of ignorance which clings to the melting pot of our society.

This paper looks at some of those recent developments within the NSW Department of School Education, and how they can be exploited to enable effective contributions by government agencies, community groups and individuals interested in increasing community awareness and understanding of our rangelands. Two examples of educational activity are briefly described.

# **INTRODUCTION**

A common perception of people involved with Australia's rangelands is that most of the denizens of our coastal fringe (>80% of the voting population) don't know much about the semi-arid and arid parts of the continent, and care even less. This, sadly, maybe quite adjacent to the truth. Their perspective, however much we may question or disagree with it, is of vital importance to us because they define the issues (Blair, 1993). The fact remains that there are vastly more urban dwellers than rural. The power of the populous is such that the city dweller has a greater voting power, and as consumers, more purchasing power. One way of raising the profile of our rangelands is to provide information to school students.

# **CHANGES**

Over the past few years, as a result of recommendations from various reports, there have been some significant changes in the operations of the NSW Department of School Education (DSE). There have been some changes in other states as well, as Education Departments and others come to grips with a trend towards national standards in school education. Some of those changes, outlined below, are significant in that they have created a demand for information and experiences for school students in the form of up-to-date, innovative teaching resource material. Some of this demand may be met by providing material with a rangelands perspective. In doing so, there is a chance of raising the awareness and understanding in Australia of the social, physical and economic dynamics of our rangelands.

Two different methods of 'using the system' to achieve education goals are cited. The first outlines the current production of a series of "rangelands specific" teaching resource materials and the second is the description of a successful trip by rural community members to a "City Farm".

# KLAS, SYLLABUSES, OUTCOMES AND PROFILES

There is a bit of jargon to explain in order to understand some of the fundamentals of the changing education system. Bear with it.

In NSW, subjects are now described as parts of Key Learning Areas (KLA's). In Primary Schools (Kindergarten to Year 6), the KLAs are English, Mathematics, Science and Technology, Human Society and its Environment, Creative and Practical Arts and Personal Development/Health/

Physical Education. In secondary schools, Languages Other Than English and Technical and Applied Studies are added.

New syllabus documents for particular subjects within KLAs are produced by the NSW Board of Studies from time to time as the need arises. These needs may be due to, for instance, demand by the education system and general community for particular courses of study, changes in emphasis by the School Education Department or its political masters, or changes in the nature of the technology and/or paradigms etc. associated with the course.

A recent shift in emphasis affecting syllabus documents has been the change from teacher-centred specific aims and objectives to student-centred outcomes. Outcomes are basically what a student is expected to know or be able to do at the end of a block of study or part thereof. Basically, the question being asked to measure a course of study is; "what increase (if any) in capability has occurred in the student?", rather than "what has been taught by the teacher?"

Profiles have been introduced as a mechanism for guiding teachers and building up a reporting system which profiles students and gives an indication of their educational development. An effort is being made to bring the various State education systems into line so that some comparisons can readily be made between students in different States. A series of National Statements outlining the profiles for different learning areas have been produced in draft form, and they are now the subject of typical interstate bickering over small matters of content and semantics.

Another recent change in emphasis in New South Wales is the increased attention to, and support for, Environment Education. All subjects/learning areas are supposed to have the "environmental" aspects of that subject at least touched upon in any particular course of study. The 1989 Environmental Education Curriculum Statement "aims to help students at all levels develop the appropriate skills, understanding, attitudes and values which will help them make informed judgements about maintaining and improving the environment".

### WHAT TO DO

So we have a new ball game in this State at least, with new requirements for teachers, schools and DSE regions, and a raft of new syllabus documents which reflect the changes.

With these new emphases and changes there is a need for new, teacher-friendly outcome-based, environmentally tuned "resource materials", which fit into teaching programs and address the outcomes in the syllabus documents.

An average classroom teacher will commonly use what is called 'resource material' in order to facilitate learning and illustrate a particular fact, process or idea. The resource material can, and often is, constructed by the teacher using various reference materials and their own experiences as part of their preparation. Teachers welcome prefabricated resource material which they can easily use, is popular with students and which is directly relevant to their teaching program.

If resource materials, excursions, activities etc. with a 'rangelands flavour' can be produced/ orchestrated and used in classrooms, there is no doubt that, eventually, the community's knowledge and awareness of rangeland issues will increase.

All regions of the DSE have a specialist consultant for each KLA. These people assist those needing to access effective techniques, organise resource material for their area of expertise, and provide guidance as to appropriate classroom methods and contacts among the teaching profession. These contacts are invaluable when the time comes to write, trial in the classroom and rewrite educational products.

# TWO EXAMPLES

# 1. Sarbs

In February 1993, the Rangeland Education Unit (REU) was established at the Dubbo (Central-West, NSW) Education Resource Centre. The REU is funded jointly by the National Landcare Program, and

the Western Regions of the NSW Department of Conservation and Land Management (CaLM) and the Department of School Education. The main task of the REU is to increase the amount of information concerning rangelands in schools and tertiary education outlets, particularly in NSW.

The REU is currently producing a basic document entitled the "Semi-Arid Rangelands Broadsheet Series" (SARBS). This consists of 26 'broadsheets' (double-sided A3 sheets) containing information and instructions for activities concerning the semi-arid rangelands of NSW. The broadsheet format has been found to be generally well regarded by teachers as they are easily reproduced and are of a size that students find easy to work with. The format and information are being produced in consultation with CaLM staff, classroom teachers and KLA consultants. The sheets include references to relevant outcomes from the new syllabus documents produced by the Board of Studies. There is scope for adaptation of the material in the broadsheets for adult education and interstate use.

# 2. Ivanhoe Landcare Group, Sydney Visit

The concept of taking the bush to the city came from an ABC radio interview. This show talked of a survey done in Sydney at a number of schools with students from a cross section of ages. The survey was designed to ascertain if students could relate supermarket shelf products with farm produce. The results showed that approximately 80% of the surveyed students had difficulty in doing so. These sort of statistics should be disturbing to those of us who are connected with rural industries and lifestyle.

Ten graziers from the Balranald/Ivanhoe area in western NSW decided that it was time to take some steps towards rebuilding the relationship between city and rural dwellers. The graziers would take the bush to the city with the intent of heightening the city dwellers' awareness of rural issues and forming bonds with urban groups that could act as information exchange channels for the future. The trip would also give the graziers the opportunity to "feel out" the city dwellers' perceptions of rural life.

After some discussion, it was decided that an appropriate method of reaching some urban students would be to present information about the west of the State at the Calmsley Hill City Farm, in the outer western suburbs of Sydney. Calmsley Hill comprises some 186 hectares which is being rapidly engulfed by the expanding urban sprawl of Sydney. The farm is set up to give urban dwellers a taste of rural life and exposure to some of the issues which affect country people. Obviously, one cannot experience the agony of drought, the spectacle of sunset over an uninterrupted horizon, or the smell of red earth after rain, but a small taste is better than no taste.

Each grazier had the task of choosing a topic which would represent a realistic aspect of living in the NSW rangelands. Topics ranged from health and education to Landcare and land degradation issues. In consultation with teachers at the target schools and the Rangeland Education Unit in Dubbo, worksheets were prepared. The activities and information contained in the worksheets were crafted so as to be directly relevant to outcomes noted in various syllabus documents and would be directly relevant to the information presented by the graziers. To aid the students in understanding some of the common terminology used by the graziers, a glossary of terms was provided including such terms as woody weeds, feral animals and crutching. The visual aids, so important in 'live' presentations, ranged from large photos of flora and fauna, drought and flood, and shearing sheds to maps, fox skins, fleeces, live saltbush and a bucket of good western soil.

A 'dummy run' of the presentations was organised to give each speaker increased self confidence and an idea of timing for their talk. Constructive criticism at this stage was necessary, and while it may have appeared harsh at the time, it was very much appreciated when the time came to address the students.

The first group of students encountered were Year 5/6 primary school students (nine, ten and eleven year olds) from Villawood. Fortunately, children of this age have not developed social complexes or many inhibiting preconceived ideas. Their ideas of Landcare and the outback are formulated largely from Crocodile Dundee and Uncle Toby's ads. The students from Villawood spoke 34 different languages with approximately 70% having parents not born in Australia. This group was typical of all the school groups that were encountered during the week-long visit.

The enthusiasm and interaction of the primary school students was a great confidence booster for the graziers. The most difficult concept the children had in grasping was that of distances and the spatial relationships out west. The distance to school, to visit friends or just collect the mail fascinated the students. Upon inquiry, it was revealed that many of the students had not even seen the ocean, which was no more than 20 kilometres away.

Secondary school students (Years 9-11, 13 to 16 year olds) were generally found to have, at best, a vague concept of rangeland geography or rural issues. Many students were horrified to discover that rural people will kill a sheep for food. When asked where the meat they ate at home came from, it was only then that the connection was made between the living animal and the supermarket product. Some of these students were doing Year 11 Geography, but still had no grasp of some fundamental concepts of rural life. Many of the students of Asian background were very reluctant to handle a staple of wool. They said it was smelly, oily and generally unpleasant, and in many cases refused to handle it. A finished garment of wool was, however, seen as soft, warm and attractive. These experiences emphasised the importance of education at a grass roots level.

The trip was a success in many ways. There was a great deal of media coverage of the event, and the graziers (men and women) involved came away with enhanced public speaking skills, a boost in self confidence and an informative exposure to children with different cultural backgrounds. The teachers were impressed by the impact of the "lessons" as they were presented in an innovative way with an up-to-date format. Tired but happy, the graziers from the west went home satisfied that they had done a small bit to change attitudes through the presentation and interchange of information.

#### CONCLUSION

If we are serious about retaining a high level of knowledge about rangeland dynamics amongst land managers, and establishing a base for widespread community support for ecologically sustainable and profitable rangelands, then teachers throughout Australia must be provided with user-friendly, effective and up-to-date resource material that deals with a rangelands perspective on life.

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# WORKING WITH A RECALCITRANT LAND: MAINTAINING CONSERVATION VALUE AND IMPROVING ECONOMIC PRODUCTION OF AUSTRALIA'S NORTHERN LANDS

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### **ABSTRACT**

The overall conservation record in north-western Australia is good. Little clearing has occurred. The fauna is nearly intact. Weed and animal pest problems are less than elsewhere. However, this is success borne out of relative failure in developing the north. Modern transport and communications are now changing the economic prospects. Other industries are changing the rangelands into multiple use lands, creating the opportunity to improve economic viability in a sustainable way for all relevant industries. This is likely to be possible only by maintaining the conservation value of the land.

There are a number of important issues that need to be addressed by industries and researchers if northern Australia is to achieve a prosperous future. They include: coping with soil infertility, abandoning the quest for the supergrass, planning for a declining groundwater resource, minimising tree clearing, determining the resilience of different savannas, using fire more strategically, determining optimal collaboration between industries in land use and research, identifying critical refuges for conservation, acquiring Aboriginal knowledge of native ecosystems, and dealing with changing sociopolitical circumstances.

"...I have no hesitation in saying that the country I have discovered on and around the banks of the Adelaide River (NT) is more favourable than any other part of the continent for the formation of a new colony .... I feel confident that, in a few years, it will become one of the brightest gems in the British Crown" (Stuart 1865).

"Of the factors that have plagued the white man's efforts in this recalcitrant land, three stand out above all others: sheer geographic distance, a markedly seasonal climate, and ignorance" (Bauer 1963).

# THE ENVIRONMENTAL AND HISTORICAL CONTEXT

Australia is a special place. The infertility of the soil and the climatic variability are the most extreme of all continents, which after a long period of relative isolation have resulted in a highly characteristic biota (Braithwaite 1990). The eucalypts, the phyllodinous acacias and many of the vertebrate groups are distinctively Australian. The radiation of some biotic groups clearly results from the abundance of particular resources (e.g. parrots and honeyeaters), but others are substantially due to historical isolation (e.g. marsupials) (Braithwaite 1990). Although Australia is not especially rich in species, it has the highest number of endemic mammals and reptiles, is second highest for birds, and third highest for amphibians, of all the countries of the world (Groombridge 1992).

Europeans were able to take over the temperate lands of much of the world because of the rapid and almost automatic triumph of the plants, animals and diseases they brought with them (Crosby 1986). The imposition of a neo-Europe onto this continent has been particularly environmentally brutal. In southern Australia, the modification of nutrient levels and the accommodation of a fluctuating water supply has been done at considerable cost to this unique environment, including its biota (e.g. Saunders *et al.* 1990). For example, the geographic distribution of mammal species loss shows the difference in environmental impact between north and south very clearly (Woinarski and Braithwaite 1990).

The development of a European culture in northern Australia has been characterised by much failure. Northern Australia is not only Australian but also tropical. This was stretching the classical European paradigm of wheat, sheep, cattle, etc., too far. The additional tyranny of distance was also too much. Following a period of post World War II idealism, the view best articulated by Davidson (1972) came to dominate. In a nutshell, anything you can do in northern Australia, you can do in southern Australia cheaper and better.

This view has now changed. The impetus of the post-Cyclone Tracy reconstruction of Darwin flowed into generous federal funding associated with self-government of the Northern Territory in 1978. The changes in defence policy after the Vietnam War have seen a gradual build-up in defence expenditure

since the early eighties. However, these increases in expenditure have been rendered so much more effective by the dramatic improvements in transport and communications. The National Highway System, the airport redevelopments, improvement of the telephone system through the Rural and Remote Area Program, mobile telephones, facsimile machines, Email, television via satellite, improvements in availability and quality of helicopters, fixed-wing aircraft, road trains and four-wheel drive vehicles are all important developments (Chambers and Wellings 1992). These and other technical military developments have made the defence of northern Australia possible. The current policy of "transparency" (showing neighbouring countries that Australia is militarily capable through joint exercises, Anon. 1993a) has made Australia's increasing involvement with Asia more feasible. Further, it gives the north a greater role as a gateway to Asia.

Currently northern Australia (above 26th parallel) has 5.4% of the population, contributes 6.2% of the GDP (Gross Domestic Product) and accounts for 28% of the value of overseas merchandise exports. In northern Australia, the mining sector contributes 26% of its GRP (Gross Regional Product), compared with a contribution of 3% for the rest of Australia. Other sectors in northern Australia which contribute more than the mean 6.2% GDP are agriculture (9.3%), electricity (8.9%) and recreation, accommodation and personal services (6.8%). However, 89% of merchandise exports originate from the mining sector and 9% from the agricultural sector (ASTEC 1993). In the northwest, tourism is far more important than agriculture (Table 1) and is likely to continue to increase disproportionately as it is servicing the likely growth sector of the tourism market (e.g. PATA 1992).

Table 1. Gross Regional Product (in millions of Australian dollars) of the regions of northern Australia for the three main industry sectors for 1989-90 (from Harris 1992, Table 4). The percentages in parentheses refer to the allocation of each industry across the three regions.

Industry	Northern	Northern	Northern
	Queensland	Territory	Western Australia
Agriculture	1211 (92.8%)	50 (3.8%)	44 (3.4%)
Mining	2690 (51.0%)	847 (16.1%)	1736 (32.9%)
Tourism	650 (69.2%)	230 (24.5%)	58 (6.2%)

<sup>&</sup>lt;sup>1</sup>Recreation, accommodation and personal services.

Savanna vegetation of grassland with trees dominates the landscape of northern Australia (Mott *et al.* 1985). Savannas in other parts of the world are besieged with almost overwhelming problems of overpopulation, political instability and mismanagement, and desertification (Young and Solbrig 1992). The relative lack of development in northern Australia creates a splendid opportunity to plan an ecologically sustainable and prosperous future, something impossible for most other parts of the world. This paper explores elements of this possibility from the viewpoint of an ecologist.

### A LAND ETHIC

Aldo Leopold died in 1948, but his influence remains. His message, embodied in his classic "A Sand County Almanac", is as relevant as ever and is very much in the spirit of Landcare (e.g. Anon 1993b). For Leopold, an ethic, ecologically, is a limitation on freedom of action in the struggle for existence. All ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts. Their instincts prompt them to compete for their place in that community, but their ethics prompt them also to co-operate (perhaps in order that there may be a place to compete for). Leopold's land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively, the land. Land-use ethics are still governed wholly by economic self-interest, just as social ethics were over a century ago. It was inconceivable to Leopold that an ethical relation to land could exist without love, respect and admiration for the land, and a high regard for its value. He means something far broader than economic value - he means value in a philosophical sense. A land ethic, then, reflects the existence of an ecological conscience, and in its turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity (Leopold 1949).

### RESEARCH ISSUES FOR A LAND ETHIC

# The Quest for the Supergrass

Over the last hundred years, much effort has gone into finding exotic plants which are more nutritious, productive and drought resistant than the native species. Such attempts at pasture improvement for raising cattle have ranged from low maintenance additions of species to native pastures to exotic cropping systems which totally replace the native ecosystems (e.g. Winter *et al.* 1985). Legumes which fix nitrogen and thereby improve nitrogen levels in the soil have been a particular target in the quest (e.g. McIvor *et al.* 1981).

Panetta (1993) has shown that of 220 exotic plant species that have been proclaimed noxious in Australia, at least 46% were introduced intentionally. Lonsdale (1994) has demonstrated that between 1947 and 1985, 463 exotic grasses and legumes in at least 2033 accessions were intentionally introduced to north-western Australia, the grasses mainly from Africa, and the legumes mainly from Central and South America. Of these, only 21 (5%) came to be recommended as useful, but 60 (13%) became listed as weeds. Seventeen of the useful plants were in fact also weeds, leaving only 4 species (<1%) that were useful without causing weed problems. They were far outnumbered by the 43 species (9%) that were weeds but had no recorded use. Of the 60 weeds, 21 were weeds of cropping, 20 were weeds of conservation and 19 were weeds of both. Thirteen in fact were major crop weeds.

This story of introductions is an appalling record of failure and misguided pursuits. Further, the annual production rate of the cattle industry of the Northern Territory works out at \$1.48 per ha, while weed control is roughly \$30 per ha for annual weeds and \$120 per ha for woody weeds (Lonsdale 1994). Only 3%, 0.1% and 0.14% of Queensland, Northern Territory and northern Western Australia, respectively, have actually been sown to these species as improved pastures. Given the poor adoption rate, it is clear that we need much closer scrutiny of proposed introductions. Lonsdale (1994) proposes a process of national cost-benefit analysis to minimise the impact of further introductions.

The pattern is now plain: it would be irresponsible to continue without decisive changes in recommended best practice concerning the introduction of exotic plants.

# Living with Infertility

The savannas of north-western Australia are infertile (Mott *et al.* 1985). However, the studies of Winter (1990) in the Katherine region show that at least some native pastures in the region can, with careful management, produce live weight gains approaching those of improved pasture systems in the same region (*cf.* Mott 1986). There are two principles involved. First, use of mineral licks to put the nutrients needed directly into the cattle rather than via the pasture. Second, use of fire to move the feeding and trampling activity of cattle about and so avoid the formation of soil seals which prevent subsequent plant growth and thus loss of pasture. These inputs are a less costly option than improved pastures, and result in higher profitability (Andrew 1986, Foran *et al.* 1990). As the latter authors point out, research should focus on increasing the long-term profitability of pastoralism, rather than the short-term productivity of land.

# The Dry Future

The use of savannas by humans depends on the availability of water throughout the year. There is heavy dependence on groundwater for irrigation, stock and human use during the long and intense dry season. Recently Warren Muller and I have generated a regional index of groundwater availability. This index is based on data from 16 unexploited bores throughout the northern half of the Northern Territory. The groundwater levels increased substantially throughout the 1970s and decreased by a commensurate amount throughout the 1980s. In the 1990s we are currently at levels similar to those of the 1960s. Obviously the unexploited groundwater levels are determined by rainfall. They are best correlated with an eight-year running mean for both Darwin and Alice Springs. Using the long-term rainfall data, it is possible to estimate past levels of groundwater. It is clear that we have just been through the best groundwater levels since we started recording rainfall last century. The future is likely to be one of much lower groundwater levels, and it will be necessary to plan carefully our future use of groundwater.

# Understanding Resilience

Resilience is the ability of an ecological system to return to its previous state after perturbation. It is a property of ecosystems that varies considerably. All accounts of historical land degradation in Australia draw attention to the lack of resilience of much of the land and its consequent sensitivity under intervention (Messer 1987). Garry Cook and Dick Williams are studying the resilience of savannas to determine which are able to take heavy use and quickly return to good condition after grazing pressure is removed and which savannas are very slow to recover. They are examining a wide range of combinations of mean rainfall and soil types as surrogates for the primary determinants of savanna structure and function, plant available moisture and available nutrients respectively (Frost et al. 1986). The outcome of this research should be very important for planning land use and management in the future (see also Cook and Williams, this volume).

# **Removing Trees**

There is a long and only partly rational tradition of removing trees to generate more pasture. Clearly, removing trees from the former mountain ash forests of South Gippsland was going to greatly improve the value of land as pasture. However, too often clearing land has been more to do with symbolism: its economic value has been hotly debated for a long time. For example, "The very rapid spread of ringbarking in spite of the opposition of lovers of fine scenery, and of so many scientific men ....proves that there must be a clear gain to the graziers in getting rid of the timber" (Abbott 1880). The writings of that time are full of self-justification, using erroneous ecological speculation about flood control, human health and such (Bolton 1981). It is now clear dead trees had quickly come to symbolise progress, development and taming of a savage land.

In northern Australia, with its high light intensity and low nutrient availability, growing more pasture was never likely to be the problem. The focus has been on growing better pasture and should be on how to get adequate nutrients into stock (see above). Typically, agricultural scientists put caveats on tree clearing. For example, "Firstly, landscapes likely to suffer from salinisation should not be cleared, although such landscapes may not be easy to recognise. Secondly, land with steep slopes, unstable soils or economically uncontrollable regrowth also should not be deforested. Thirdly, the graziers philosophy of overgrazing must also change." (Gardiner *et al.* 1990).

While Burrows (1990) cites evidence of substantial increases in carrying capacity and weight gains with woodland clearing, others (Gillard *et al.* 1989, Winter *et al.* 1989) find no such effects. The positive effects may in fact be short lived due to readjustments in the nutrient economy resulting from re-allocating the nutrient pools associated with the trees.

Clearing in general seems to have strong negative effects on the conservation of fauna and flora, on ecological processes, on long-term sustainability, and on the aesthetics of the distinctive Australian landscape (e.g. Tyndale-Biscoe and Calaby 1975, Seddon and Davis 1976). This is balanced against uncertain but minor short-term economic advantage. We are now at a point where very strong arguments should be needed for clearing in a specific situation.

### **Restoration Revisited**

Woods (1983) estimated that over 22% of the entire savanna region showed signs of degradation. Restoration of degraded land currently occurs on an intensive basis. It generally uses heavy machinery and intensive care to make it happen. Clearly if enough resources are put into it any land can be restored. Although the level of degradation is not high by most standards, there is a problem with economically restoring land which has low economic potential and is remote and with poor access.

The technology needed probably parallels the solution to the problems of survey, surveillance, cattle mustering, pest control, remote medical assistance and fire management: the use of aircraft. We need to develop aerial techniques for restoration, using capsules of whatever is needed (seed, nutrients, gypsum, mulch, even soil) which can be dropped in numbers from aircraft. The shape and matter of the capsule would be determined by whether it was desirable to penetrate the soil or burst on impact or to remain intact until rains dissolve the capsule or until protection is no longer required by seed or even seedlings.

# The Curse of Fire Management

The community currently dedicates considerable resources to prescribed burning across the vast tracts of northern Australia. Increasingly, this burning is done from helicopters and fixed-wing aircraft. As this activity is no longer limited by access problems, it is now possible for the burning to be more and more strategic. Just as Aboriginal people used to impose their control on the landscape by burning a patchwork into it early in the season with large numbers of people on foot (Braithwaite 1994), it is now possible for a much smaller number of people to simulate an approximation of this pattern with aircraft.

As mentioned above, using fire for spelling pasture from overuse is a valuable management tool (e.g. Andrew 1986). Just as Aboriginal people did, pastoralists can also use fire to generate re-sprouting of highly nutritious grasses. The timing of such fires in relation to landscape position for pasture production is important. Such tactical burning is only possible with safety after the landscape has been placed under effective fire control by strategic burning. Understanding fire behaviour and effects is valuable for the skilful management of grazing lands.

The curse is that fire has such a bad public image. Further, it is so complicated in its biological effects (e.g. Lonsdale and Braithwaite 1991) that it is difficult to convince the public that burning is in the common good. Human responses to fire are also confounded by numerous life experiences (see Braithwaite 1994). People need to be convinced we know what we are doing.

# Sharing the Northern Lands

Although technological advances have improved the delivery of basic services like health care and communication, they have not helped increase agricultural or pastoral output. The environment still has its limitations, but the commodity prices have dropped for external reasons (Holmes and Mott 1993, Harris 1992).

The pastoral industry pioneered the northern lands late last century bringing European culture to the landscape. Aboriginal people were largely absorbed into the pastoral industry as its servants. Apart from sharing the lands with the military during World War II, pastoralists have had near exclusive domain. This began to change and quickly, with the social and international economic changes of the sixties and seventies. The decline in profitability of beef has been accompanied by the increasing importance of mining, and since the eighties, tourism. Also, many properties have now been sold to Aboriginal communities.

Aboriginal people now own about 50% of the Northern Territory. Their use of the land shows signs of being diverse, from traditional Aboriginal to traditional pastoral, with ecotourism, mining support and a diverse range of craft manufacture to varying degrees. While their traditional use of the land is of economic value in defraying social security costs, they are increasingly significant players in the economy of the north through their participation in the European market economy (Crough 1993).

The military are again important players. The Defence Department policy of "transparency", where the capability of the Defence Forces is put on display in the north with elaborate and convincing exercises done jointly with forces of neighbouring countries (Anon. 1993a), will ensure increasing use of the landscape. As a corollary to this, renting exercise space and facilities is also becoming increasingly prevalent. Economically this is an important use of the land.

So a quiet revolution in land use in northern Australia has been taking place. All the players, both old and new, need to accommodate aspects of this in their thinking.

# What is Tourism Really About?

Surveys show the main motivation to visit the Northern Territory is the interest in its natural attractions. What visitors liked was its uniqueness, climate, vastness, unspoilt nature, wildlife, friendly people and relaxed lifestyle. Their dislikes included restrictions on where they could go, insufficient things to do, lack of native animals and littering (Market Equity 1993).

The recent Kakadu National Park tourist survey showed the perceived needs for additional facilities and services were overwhelmingly concerned with getting more information (including knowledge of Aboriginal culture, native plants and animals, and geology), access to tour guides, more signs and better maps. Already "too many people" is emerging as a major factor detracting from the enjoyment of a number of the Kakadu sites (Environment Science and Services 1994).

Tourism is about both creating and meeting demand. As many places around the world have discovered, satisfied customers are the key to survival of any tourist destination (e.g. Butler 1980). The messages are clear. There is a need for a far more extensive use of the northern Australian landscape by tourism operators. However, much more information must be made available if satisfaction is to be achieved. New information, both planning and interpretation, is needed and information already available must be put into the hands of the industry (Braithwaite 1993).

### Clean and Green Cattle

Stafford Smith and Foran (1993) cogently argue that the best future for meat production from commercial rangelands in industrialised nations anywhere in the world is to work towards capturing an important future niche - that of free-range, low residue products grown sustainably on lands which do not compete for more intensive agriculture. As Stafford Smith (1993) points out, there are three vital implications of such an approach for management. First, the industry must develop a coherent goal and image which differentiates it from the remainder of Australian production as clean, green and free-ranging. Second, the provision of such a product demands reliability and quality of supply, which almost certainly means maintaining lower stocking rates. Third, the industry must establish monitoring programs capable of demonstrating the land is not deteriorating and current practice is genuinely sustainable not only in terms of maintaining the pastoral enterprise but all ecological functions and biodiversity of the region.

# **Protection of Refuges**

In this environment of variable climate, there are special places on which some species depend for their survival. Species generally fluctuate spatially through time. For example, the Northern Quoll, *Dasyurus hallucatus*, occurs across northern Australia and is currently shrinking in distribution to six major rocky escarpment areas (Braithwaite and Griffiths 1994). It is now disappearing from the savanna country. In the mid-eighties, the species relied strongly on the environment around and including waterholes. The dominant and most reproductive animals lived closest to the waterhole. Now the waterholes dry up early in the year due to the low groundwater levels (see above) and the animals are disappearing from many savanna areas. Such fluctuations have occurred before as shown by their total absence from the Tiwi Islands but continuing presence on the more rocky Groote Eylandt (Braithwaite and Griffiths 1994).

Savanna species which are not able to prosper or survive in rocky areas are in a much more vulnerable situation. Such species depend on refuges within the savanna, particularly creekline areas. Such areas are sources of free drinking water, sites of prolonged seasonal primary productivity, and areas of greater heterogeneity, all features which not only make them attractive to native fauna but also to exotic fauna like cattle. Many of these refuges are now piospheres or areas of localised degradation around a water point caused by introduced stock (e.g. Graetz and Ludwig 1974).

While an improved reserve system is necessary with additional reserves in the north Kimberley, south-west Kimberley, northern fringe of the Tanami Desert, Gulf of Carpentaria hinterland and eastern Arnhem Land highly desirable (Woinarski 1992), it is far from sufficient. Ecological sustainability requires the protection of some proportion of these refuge areas. Conservation fencing is increasingly being employed as part of Landcare programs in southern Australia and is also very appropriate in the north.

# Utilizing Aboriginal Knowledge

Above I have discussed issues requiring research or where research has already shown that the short-term economic gain of a particular practice is so minor as to be uncertain. However, the broader conservation value is often clear. Ultimately, the health of the land benefits all. The eloquent words of Leopold and others on a land ethic describe a relationship not unlike that of indigenous huntergatherers (e.g. Durning 1992). Rose (1988) has pointed out that traditional Aboriginal people have this kind of land ethic. While the cross-cultural communication problems are substantial (e.g. Braithwaite 1992), the benefits can also be substantial (e.g. Reid *et al.* 1992).

# CONCLUSION

We are in a time of social change. We read and hear a lot about Australian culture (e.g. Carroll 1982, Thornhill 1992) - what it is, what its essential characteristics are, and what are the threats to it. One of the things which comes through to me is our ability to deal with unusual, tough, difficult

circumstances. As individuals and as a society, we are flexible and adaptable. We are not afraid to try something new. This gives us a confidence in the future, something you do not encounter much overseas. Australia is perhaps unique in this regard. However, we must deal with the real world rather than myths. Embracing a land ethic must be part of that process. Ultimately this must be our salvation and ultimately this will see the north prosper.

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### CAN PASTORALISM AND BIODIVERSITY CONSERVATION COEXIST IN THE RANGELANDS?

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### **ABSTRACT**

Since the arrival of pastoralism in the rangelands, biological diversity has changed dramatically. Some of the changes are directly attributable to pastoral activities but some are not. There are complex interactions between the impacts of domestic, feral and native grazers, feral and native predators, changed fire regimes, clearing, introduced plants and increased availability of water. Pastoralism and biodiversity conservation can and should coexist in the rangelands, but only where pastoralism continues to be economically and ecologically viable. Regional reviews of land use which consider all community aspirations for the land are necessary, but the degree to which biodiversity conservation is achieved will depend on the community's willingness to accept the social and economic costs.

### INTRODUCTION

The Convention on Biological Diversity (Anon. undated) defined biodiversity as: "the variability among living organisms ... and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems". In other words, biodiversity is a multilayered concept; it is not simply species richness.

Up to four levels of organisation are recognised by writers (e.g. Noss 1990): genetic, species/population, community/ecosystem and landscape/region. Each of the levels can be characterised by attributes of their composition, structure and function (Table 1). To add to the complexity, these can vary in time as well as space. I will deal only with the latter three levels because of the dearth of information at the first, genetic level, although I recognise that pastoralism must have an impact on all four.

In this paper I review some of the changes that have occurred in rangelands biodiversity and examine the causes. With this background, I then consider how conservation of biodiversity might best be achieved.

# CHANGES IN THE BIODIVERSITY OF RANGELANDS

### Landscape/region

Since European settlement, there have been major changes in some vegetation types. For example, the Atlas of Australian Resources (1990) suggests that chenopod shrublands classified as Low Shrubland (10-30% foliage cover) are now largely Low Open Shrubland (<10% foliage cover). Significant areas of Low Woodland in NSW and Qld have been converted to Low Open Woodland through clearing, while areas of grassy woodland (Low and Low Open) have become woodlands with low shrubs due to the development of "woody weeds". These structural and compositional changes will invariably affect functional processes.

Information is scarce on the status of some faunal taxa, but it is clear that a significant number of mammals have become extinct in the arid zone and more are endangered (Table 2). While no birds are known to be extinct, a number are endangered. The density of kangaroos has increased in some regions and feral species such as rabbits and goats are widespread. Dingoes have been largely eliminated from extensive areas.

# Community/ecosystem

Vegetation and soil in their "natural" state are patterned at a variety of scales. In some communities, like various arid and semi-arid mulga woodlands, one obvious level of pattern is the treed and treeless zones of the groves and intergroves. In others, like some chenopod shrublands, the dominant pattern to the human eye is at the scale of the individual plant. The different components of patterned

environments vary in the quality of the resources they retain. Some components tend to shed water, nutrients and seeds, while others tend to gain them, creating characteristic runoff-runon patterns (Tongway 1994).

**Table 1.** Some attributes of biodiversity at three levels of organization, appropriate to rangelands; from Friedel & James (in press), modified from Noss (1990).

Composition	Structure	Function
Landscape/region		
Identity, distribution, richness and proportion of patch (habitat) types; collective patterns of species distributions	Heterogeneity; connectivity; contrast; grain size; patch size frequency distribution; perimeter-area ratio	Disturbance processes (e.g. areal extent), frequency, intensity and seasonality; nutrient cycling rates; energy flow rates; patch turnover rates; rates of erosion, and geomorphic and hydrologic processes
Community/ecosystem		
Identity, relative abundance, frequency, richness, evenness and diversity of species and guilds; proportions of e.g. endemic and exotic species; dominance-diversity curves; life-form proportions	Soil variables; vegetation biomass and physiognomy; horizontal patchiness; abundance, density and distribution of key physical features (e.g. sinks), and structural elements (e.g. log mounds)	Biomass and resource productivity; herbivory and predation rates; colonization and local extinction rates; patch dynamics (fine scale); nutrient cycling rates
Species/population		
Absolute or relative abundance; frequency; importance or cover value; biomass; density	Dispersion; range; population structure; habitat variables (see above)	Demographic processes (e.g. fertility), recruitment rate, survivorship and mortality; life history; phenology

**Table 2.** Extinct and endangered species in Australia's arid zone (from Pickup, Griffin & Morton in press)

Taxon	No of extinct species (%age of all arid zone species)	No of endangered species (%age of all arid zone species)
Flowering plants	6 (0.4%)	8 (0.4%)
Invertebrates	?	?
Fish	0	0
Amphibians	0	0
Reptiles	0	0
Birds	0	19 (8%)
Mammals	11 (12%)	20 (22%)

Some types of change mentioned above in *Landscape/region* result from disruption of runoff-runon processes by grazing and trampling. Once the structures which hold resources in place, whether groves, plant hummocks or individual tussocks, are damaged beyond a certain point, the resources are washed or blown away, and/or soil quality declines. The arrival of sufficient eroded material from elsewhere will also affect a community at the receiving end. In either case, the diversity of composition, structure and function will no longer be the same. Erosion/deposition rates will have altered and production will be differently distributed.

The impact of grazing animals on biodiversity is not uniform. Livestock grazing is focussed on watering points and on preferred communities. The effect on an individual community will be dependent on the mix of other types in the vicinity. Within a community, patches of vegetation will be preferred because of shade, prevailing winds, local runon areas and so on.

Most of these kinds of change have been recognised in vegetation/soil properties. There is little equivalent information for native fauna. Despite reasonable argument that patterns of vegetation and soil will affect the distribution and abundance of faunal species, the evidence is sparse (but see C.D. James in Friedel & James in press). Consequently, evidence of any impact of changing vegetation and soil patterns on fauna is also lacking.

# Species/population

Suffice to say that, as the foregoing suggests, there have been changes in attributes of abundance, demography and dispersion of individual native plant species. It must be assumed that the same is true for fauna at a local level, as well as at the landscape level as already outlined. In addition the introduction of non-native plants such as buffel grass (*Cenchrus ciliaris*) has without doubt affected the attributes of native species and populations.

### AGENTS OF CHANGE

Pastoralism has had a wide ranging impact on the rangeland through activities such as removal of cover, species selection and trampling of soil. Its effects on plant communities have been widely documented (e.g. Wilson & Harrington 1984). Although data on fauna are scarce, it is reasonable to assume that there is a causal link to loss of faunal diversity, through damage to habitat.

While pastoralism is the major land use in the rangelands, livestock grazing is by no means the only agent of change: other grazing mammals are also active. The importance of kangaroos, goats, rabbits, camels and donkeys varies regionally. Most of them are not restrained by livestock fences, and rabbits are independent of watering points, so that their impacts within communities are different too.

Fire regimes are no longer what they once were. Prior to the introduction of pastoralism, the size, intensity, frequency and distribution of fires would have imparted a pattern to landscapes and communities which is now gone. Active fire suppression and consumption of fuel by grazers has assisted the development of shrubbiness and greater uniformity where once there had been firepatterned grassy woodlands.

Exotic plant species intended to enhance native pastures or to assist in rehabilitation have spread far beyond their introduction sites. Buffel grass has invaded resource-rich habitats such as river frontages and restricted moist habitats which harbour many rare and relict native species (Griffin 1993).

Clearly these factors interact variously to produce changes to faunal habitat, but their impact is complicated by the presence of feral predators such as foxes and cats and, in some cases, by the absence of dingoes. Livestock grazing has been implicated in faunal extinctions by many authors (e.g. Dickman *et al.* in press), and they may well be right, but there is no unequivocal evidence.

On the other hand, the densities of various kangaroos and euros and of emus have increased in some areas since the introduction of pastoralism. The cause is not grazing itself, but probably the provision of many watering points as well as the elimination of dingoes.

# INTEGRATION OR DISPLACEMENT?

Is it possible to maintain livestock grazing industries and conserve biodiversity at the same time? The simple answer is that there is no real alternative. The biodiversity of the rangelands is too great to be represented in existing park systems, and the community cannot afford to acquire and manage large additional tracts of land. Instead, we must accept that biodiversity conservation and productive use of land can and do coexist in many areas.

This is not to say that all existing pastoral areas should remain so. It is apparent from recent reports (e.g. Wilcox & Cunningham 1994) that, in particular, the pastoral sheep industry is not economically viable across broad regions of the rangelands, although individual enterprises may be successful. In the not too distant future, existing land use will have to be reviewed in the context of community objectives, at a regional level. Within particular regions, local as well as wider aspirations for land use will have to be weighed up, and a negotiated process of land use allocation will have to take place.

This does not mean that all previous uses will be discarded and replaced. Instead, existing uses will be focussed where they are most appropriate, and sometimes they will co-exist with new uses. Ultimately, society must decide how much change is socially, economically and ecologically acceptable.

Where conservation of biodiversity is identified as an important land use within grazing lands, the two uses can be integrated. In some cases, areas of high quality for conservation within individual properties will need separate management but, over broad areas, the requirement will simply be for ecologically sustainable management (Morton *et al.* in press). Conservation is a regional-level goal, and it is unrealistic to expect every species to remain unchanged within individual pastoral properties. The basic requirement is that change that is brought about by grazing is reversible. Ecological processes which conserve water and nutrients and ensure seed supply have to be maintained, to ensure that the potential is there for vegetation recovery. In addition, imbalances and invasions of exotic and native species will have to be tackled, and not only by individual landholders. Finally, management actions will need long term monitoring and adjustment. Just how successful biodiversity conservation ultimately is depends on society's determination to bring about change, and to accept the social and economic costs.

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### THE VERTEBRATE FAUNA OF MITCHELL GRASSLANDS IN THE NORTHERN TERRITORY

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### **ABSTRACT**

The fauna of the vast Mitchell grassland plains has received little scientific attention; systematic studies have been limited to censuses of wetland birds and inventories of restricted areas. Location records within Mitchell grassland communities account for only 2.6% of the NT fauna database; 83% of records are birds. A total of 339 terrestrial vertebrate species have been recorded, but only 124 species are known from more than 10 non-duplicate records. The fauna is largely typical of semi-arid northern Australia and includes both Torresian and Eyrean elements. The NT distribution of 6 reptile species is closely associated with the extent of Mitchell grasslands, while a further 42 species apparently show some preference for these communities. The ecology of many species is likely to be linked to temporal and spatial environmental variability associated with rainfall, vegetation and substrate. A broad systematic survey sampling the range of variation is required to address our current deficiency in knowledge.

### INTRODUCTION

Mitchell grasslands are dominated by perennial tussock grasses of the genus Astrebla and occur on finely textured alkaline soils, principally grey cracking clays ("black soil"). They cover an area of c. 400,000 km² (c. 8% of Australia's rangelands) between the 250 and 550mm isohyets, with a predominantly summer rainfall (Fig. 1A). These grasslands are relatively productive and are dedicated to extensive pastoralism, being generally regarded as highly resilient to grazing. A good general account is given by Orr & Holmes (1984). Wilson et al. (1990) recognised two Astrebla grasslands (map units 96 and 97) in the NT, occurring on the extensive black soil plains of the Barkly Tablelands and Victoria River regions. A further four communities are closely related: Eucalyptus microtheca (Coolibah) low open-woodlands (26, 28) and Chenopodium auricomum (Bluebush) low open-shrubland (107) occurring on clay soils in drainage lines or depressions within or adjacent to Mitchell grasslands; and an Acacia georginae (Gidgee) low open-woodland with Astrebla understorey south-east of the Barkly Tablelands (62). Together these map units occupy 7.0% of the Northern Territory (Fig. 1B). A number of authors (e.g. Bowman et al. 1988) have recognised the Barkly Tablelands as a distinct phytogeographic region.

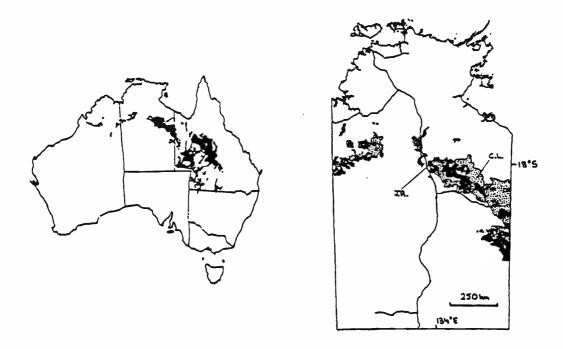


Figure 1. Distribution of Mitchell grasslands. (A) In Australia (from Johnson  $et\,al.\,1982$ ). (B) In the Northern Territory (Wilson  $et\,al.\,1990$ ). Stippled = Astrebla grasslands; solid = associated communities.

Despite their extent, biological interest in Mitchell grasslands has focused almost exclusively on pastoral productivity and the autecology of dominant grass species. This paper outlines what is currently known of the fauna of Mitchell grasslands and briefly considers some of the significant environmental attributes of this ecosystem. Analysis is confined to the terrestrial vertebrate fauna within the Northern Territory, although comments on the sparsity of information are also applicable to Queensland.

# PREVIOUS ACCOUNTS OF VERTEBRATE FAUNA

There have been no systematic investigations of the fauna over an extensive area of Mitchell grasslands in northern & north-eastern Australia. Within the NT, brief inventories of the vertebrate fauna have been undertaken in Connells Lagoon Conservation Reserve (259km²; Johnson et al. 1982) and Junction Stock Reserve (207km²; Fleming et al. 1983). Monitoring of mammal populations is being undertaken in the former area (Berman pers comm.). Greater attention has been paid to the intermittent wetlands, particularly as habitat for waterbirds (e.g. Jaensch 1994). Accounts by early explorers, settlers and naturalists contain valuable, but limited, data on some species' historical distribution and abundance.

### ANALYSIS AND DESCRIPTION OF AVAILABLE RECORDS

The Conservation Commission of the Northern Territory (CCNT) compiles and maintains a database of location records for terrestrial vertebrate species, collated from a variety of sources (Price *et al.* 1994). This currently contains *c.* 224,000 records for 754 species. Coverages of the fauna database and the NT vegetation map (Wilson *et al.* 1990) were intersected using the geographic information system ARC/INFO, in order to assign a map unit to each fauna record. Species lists for Mitchell grassland communities were compiled and the recording rate for each species calculated. Species were considered to be 'preferentially' recorded in Mitchell grasslands if the number of non-duplicate records (i.e. not at the same site on the same day) exceeded 10% of the total non-duplicate records for that species in the NT. Species' distributions and apparent habitat preference were also compared with published accounts (e.g. Cogger 1992). This allows for a preliminary description of the fauna, although this is limited by the variable precision in record locations, the limited resolution of vegetation mapping and the biases in records principally based on opportunistic observation.

A total of 5660 records were from Mitchell grasslands and associated communities. This represents 2.6% of the total NT records, an under-representation in comparison to the areal extent of these communities (7.0% of the NT). 83% of the non-duplicate records are for birds, reflecting the bias to more conspicuous taxa. A total of 356 species were recorded from all communities, consisting of 194 birds, 103 reptiles, 38 mammals and 21 frogs. However, many species, particularly non-bird taxa, were very poorly recorded. Only 124 species had more than 10 non-duplicate records; 102 birds, 16 reptiles, 5 mammals and 1 frog.

### **BIRDS**

The most commonly recorded bird species include those ubiquitous and conspicuous throughout Australia (Australian Magpie Lark, Willie Wagtail), raptors (Black Kite, Australian Kestrel, Brown Falcon, Wedge-Tailed Eagle, Spotted Harrier) and a number of granivorous species (Zebra Finch, Little Corella, Crested Pigeon, Galah, Diamond Dove, Budgerigar). Over 50 species of waterbirds have been recorded and Jaensch (1994) recognised 3 areas on the Barkly Tableland and one in the Victoria River region as wetlands systems of outstanding importance for waterbirds. Many species conspicuous in wooded northern Australia (e.g. honeyeaters) are limited to woodlands along drainage lines and are rarely recorded (Johnson et al. 1982). An analysis of avifaunal distribution in the NT (Whitehead et al. 1992) recognised a mid-latitude, "dry grassland zone", one component of which incorporated the Astrebla grasslands. Species with a preferential recording rate (Table 1) include some associated with wetlands (ducks, Yellow Chat), grassland species (Red-Chested Button Quail, Stubble Quail, Singing Bushlark) and two raptors which undergo episodic population fluctuations in response to irruptions in prey species, particularly Rattus villosissimus. Perhaps the most characteristic bird of the Mitchell grasslands is the Flock Pigeon. This species has disappeared from parts of its range in Queensland and NSW and flock sizes currently observed are far smaller than the "countless multitudes" reported last century (Blakers et al. 1984). Flock Pigeons appear to undergo population fluctuations and/or migration in response to variable climatic conditions.

Table 1. Vertebrate species with more than 10% of non-duplicate records from Mitchell grasslands communities. Figures in brackets are (number of records in Mitchell grasslands / % of total number of records for the Northern Territory). Species with a single Mitchell grasslands record were excluded and 6 reptile species with recording rates of less than 20% are not listed.

Birds		Reptiles		Frogs	
Flock Bronzewing	(46/48%)	Pseudonaja ingrami	(15/83%)	Uperoleia borealis	(4/57%)
Yellow Chat	(22/44%)	Pseudonaja guttata	(15/79%)	Uperoleia trachyderma	(5/45%)
House Sparrow	(4/44%)	Ctenotus joanae	(17/77%)	Cyclorana platycephala	(3/33%)
Great-crested Grebe	(4/40%)	Ctenotus tantillis	(6/75%)	Cyclorana maculosa	(3/25%)
Eastern Grass Owl	(3/33%)	Varanus spenceri	(20/69%)	Cyclorana cultripes	(7/23%)
Red-chested Button Qua	il (7/27%)	Ctenotus militaris	(2/67%)	Ranidella deserticola	(2/11%)
Australian Raven	(14/20%)	Tympanocryptis tetraporophora	a (5/63%)		
Pectoral Sandpiper	(3/20%)	Lerista griffini	(3/60%)		
Freckled Duck	(5/19%)	Varanus storri	(8/53%)	Mammals	
Singing Bushlark	(51/17%)	Ctenotus pulchellus	(11/48%)		
Australian Pratincole	(71/16%)	Acanthophis antarcticus	(18/41%)	Planigale tenuirostris	(2/100%)
Stubble Quail	(6/14%)	Proablepharus kinghorni	(2/40%)	Planigale ingrami	(6/21%)
Plumed Whistling Duck	(30/11%)	Diplodactylus tessellatus	(2/29%)	Rattus villosissimus	(15/19%)
Yellow-billed Spoonbill	(34/10%)	Demansia torquata	(9/26%)	Sminthopsis crassicaudata	(2/12%)
Letter-winged Kite	(2/10%)	Pseudonaja textilis	(8/24%)		
Pink-eared Duck	(46/14%)	Cryptoblepharus megastictus	(4/24%)		

# **FROGS**

There are few records for frogs, reflecting a lack of access during the wet season. Many of the species recorded are Torresian species whose southern limit approximates the northern extent of Mitchell grassland communities (e.g. Litoria inermis, Cyclorana longipes). The other species fall into two main groups; arid-adapted burrowing species (e.g. Cyclorana cultripes, Linnodynastes spenceri) and broadly distributed species associated with major watercourses, swamps and artificial water (Litoria caerulea, L. rubella, R. deserticola). One species (Uperoleia trachyderma) appears to be generally associated with black soil plains (Cogger, 1992).

# REPTILES

While a total of 103 reptile species have been recorded for Mitchell grassland communities, only 16 have more than 10 non-duplicate records. Unlike other vertebrate taxa, a number of reptiles are largely confined to the Mitchell grass cracking-clay plains, both in the NT and Australia-wide (Cogger 1992). These include the skinks Ctenotus joanae, Ctenotus pulchellus and Proablepharus kinghornii, the large goanna Varanus spenceri and the elapids Pseudonaja ingrami and P. guttata. A number of more widely distributed elapids also appear to show a preference for Mitchell grass communities in the NT (e.g. Acanthophis antarcticus, Pseudonaja textilis), as does the gecko Diplodactylus tessellatus. Commonly recorded species show a range of affinities, with many species having a broad central and northern distribution, although few species have a strictly Eyrean distribution. Many species recorded normally show a preference for rocky, sandy or arboreal habitats (Cogger 1992) suggesting that they were recorded from the margins of the Mitchell grass communities, or other environments contained within them.

### MAMMALS

The lack of systematic censusing is reflected in the very poor recording rate of mammals, with only 4 native species known from 10 or more records and 22 species recorded once or twice. The small dasyurids Sminthopsis macroura and Planigale ingrami appear to be common and widespread on the Barkly Tablelands (Berman, pers. comm.); they are replaced by P. tenuirostris and S. crassicaudata in the drier south-east. Some central Australian species reach the northern extent of their distribution here (Notomys alexis, Pseudomys hermannsburgensis); similarly some northern species are occasionally reported (Pseudomys delicatulus, Rattus tunneyi). Macropod species, likely to be associated with areas of scattered trees or near watercourses, includeMacropus rufus and Onychogalea unguifera. Possibly the most ecologically significant mammal is the Long-haired or Plague Rat (Rattus villossissimus), which undergoes rapid and dramatic population increases in favourable conditions

following good rainfall. A number of predator species, including raptors, dingoes, feral carnivores and snakes, show an associated expansion and consequent contraction in distribution, population or activity. Introduced mammals include cows, horses, donkeys, cats, rabbits, foxes and mice.

# **DISCUSSION**

The Mitchell grasslands are approximately co-incident with, and possibly accentuate, a major ecological transition from humid to arid environments in the NT (e.g. Bowman et al. 1988). The vertebrate fauna is broadly similar to other northern semi-arid ecosystems, with elements from both Torresian and Eyrean faunas, but also includes a small subset of habitat-specific species. The relatively low diversity of substrates and vegetation structure no doubt restricts the faunal diversity, although the abundance of grasses and presumably some invertebrate groups and the cracking clay plains habitat provides preferred habitat for a number of species. A major factor influencing the distribution and abundance of fauna species is likely to be environmental variation within the Mitchell grassland communities. Variation in vegetation structure and floristics, principally associated with drainage lines and swamps, increases habitat diversity and broadens breeding, shelter and feeding niches. Localised gravelly rises also have an increased floristic diversity (Allen, pers. comm.), which may be reflected by the fauna. Both the grasslands proper and wetland elements also show considerable temporal and spatial variability in response to patchy and variable summer rainfall. The subsequent variation in food resources is associated with major population fluctuation and distributional changes in fauna species, and may emphasise the importance of reliable refuge areas. The long history of pastoral use, aided by the provision of numerous artificial water sources, introduces another source of environmental variation, with a currently unquantified influence on the native fauna.

A review of current knowledge emphasises the sparsity and patchiness of fauna data and the biases and imprecision of largely opportunistic records makes their interpretation difficult. A three-year project initiated by the Northern Territory University and CCNT, with assistance from Australian Nature Conservation Agency and Australian Heritage Commission, will seek to address this gap in our knowledge. The study will incorporate a systematic survey of fauna over the northern and eastern extent of Mitchell grasslands and an investigation of the response of species' distribution and abundance to environmental variation.

# **ACKNOWLEDGEMENTS**

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### THE FUTURE OF THE GOULDIAN FINCH: RESOLUTION OF CONFLICT?

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### **ABSTRACT**

Natural resources are limited, inter-related within natural ecosystems and must be managed. Environmental management must involve greater resolution of conflict between parties. This will lead to a more integrated approach to deciding on and directing research, better utilization of resources and a better outcome for wildlife under threat. The situation of development of a mine in a prime area of Gouldian Finch breeding habitat is discussed and progress in the resolution of conflict examined.

### MINING VS. CONSERVATION

Anyone who watched the cricket match between Australia and South Africa earlier this year would know from the frequently occurring advertisements that mining is not destructive and rehabilitation is near perfect. In fact, mining was shown to be no more destructive than the burrowings of an echidna that was depicted scratching up such huge masses of sand that some earth-moving equipment in the background paled into insignificance.

Then in February's newsletter from the NT Environment Centre, there was an article reporting acidmine drainage at the Mt Todd mine, near Katherine, NT. The Environment Centre spokesman has stated that mining activities and further exploration are threatening the survival of the Gouldian Finch (*Erythrura gouldiae*), an endangered species. One of the largest breeding colonies of the finch is being intruded upon by mining activities.

So, in this apparent and possibly diverging dichotomy, where is the finch and what are the risks to it? Will it stay suspended between the two, being tugged one way and then the other. Exaggerated claims and counterclaims have appeared in the press giving meat to the cartoonists and continuing the hostilities between the sides.

In the Northern Territory, where it is unlikely that development of large-scale, potentially profitable mines will be blocked by the government, what is the solution for the Gouldian Finch and any other threatened species.

# **CHANGING VIEWS**

Conservationists over the past two decades, in particular, have gradually changed public perceptions so that we now recognize that natural resources are limited, inter-related within natural ecosystems and must be managed. Environmental management has become the management of people, environment and technology combined.

Brown *et al.* (in press) consider that for the foreseeable future, environmental management will be management of conflict and change. They examine the relationship between conflict and environmental change, stating that conflict establishes that there is more than one point of view on an issue.

- 1. **Conflict is an inevitable part of change:** it is not the result of personal failure nor the failure of the system.
- 2. Conflict is a step in the solution to a problem: it signals the opening of debate.
- 3. **Conflict is shared:** it is not the sole responsibility of any one group or set of interests.
- 4. **Conflict is a process:** it is not a result, a barrier or an excuse.
- 5. **Conflict is manageable:** but management takes time and resources.

Absence of conflict is not always desirable because it can indicate apathy, ignorance, powerlessness on the part of those affected by change or a lack of commitment to orchestrating the processes of change to minimise the disadvantageous effects, Conflict is part of the process of managing change, it is not the end result unless allowed to become so.

The five statements above represent a progression in complexity from simple to more involved. In the Northern Territory, it is possible that conservationists do not become involved in the progression process in some instances because bodies keep a fairly 'closed shop' in order to prevent situations of potential conflict from arising. Is this because mining organizations have not yet found a way to work through environmental issues with conservationists?

For example, a mining company that had *Eucalyptus tintinnans* within their lease was recommended, though not required, to check whether Gouldian Finches were in the area. *E. tintinnans* is one of the four species of eucalypts that Gouldian Finches use for breeding sites (Tidemann *et al.* 1992). At the last moment, the arrangement to take me to the site was cancelled although an assurance was made that I would be taken on the next trip. That never happened. As a result, no 'trouble' was caused for the mining company but it is possible that the Gouldian Finch was disadvantaged.

Another finch-mine interaction that needs little introduction is the Mt Todd mine, about 45 km north of Katherine. Here in the late 1980s, subject to exploration activities, a mine was proposed on the edge of one of the largest breeding habitats known for the Gouldian Finch - the Yinberrie Hills. The proposal was to establish the mining infrastructure within the Yinberrie Hills and flood an area containing Gouldian Finch nest sites by building a dam to supply fresh water to the mine.

Looking at this situation against Brown et al.'s framework, conflict as an inevitable part of change, there was a rapid, forcefully expressed opposition on the part of the 'green lobby'. The Minister for Conservation said that a way to compromise had to be found. Personally, I felt that the 'system' had failed and that the Gouldian Finch was going to be the loser. I should have realized that, while not saying it openly, the government was keen, for economic reasons, to have the mine proceed. So, at that time, I did not proceed to the next 'level' where conflict was a step in the solution to a problem. The environmentalists did, and they pursued the 'opening up of debate' with tireless vigour; although for them there was only one solution - no mine.

**Conflict was shared** but hardly with the mine proponents and environmentalists proceeding hand in hand. Lots of time and energy were expended by both sides in trying to establish that the Gouldian Finch was either damned or not damned. **Conflict became a process** but the dichotomy widened with claims and counterclaims being made.

The energy of the environmentalists was matched by the determination of the mining proponents but already there was some compromise. The mining company agreed to shift the infrastructure from within the hills to outside to minimise the disturbance to the breeding site. The company also agreed to provide funds to the World Wide Fund for Nature to assist the Conservation Commission of the NT with research into the ecology of the Gouldian Finch. Research grants were also given to other bodies, one of which chose to search for breeding sites of the Gouldian Finch in Western Australia.

All the research contributed new information on the Gouldian Finch. In my opinion, however, the search for new sites in Western Australia was irrelevant to the situation of the Gouldian Finch in the Yinberrie Hills. No-one had established either that (i) the finches were genetically indistinguishable across their NT-WA distribution; or (ii) that populations regularly moved large distances east-west between the Yinberrie Hills and Western Australia. Small blood samples were collected from Gouldian Finches in the Yinberrie Hills and Timber Creek, NT, and further afield, for analysis of mitochondrial DNA. Although the analysis is incomplete, results so far indicate that the Yinberrie Hills population of Gouldian Finches differs from those at Timber Creek, about 250 km to the west (Martin Elphinstone, pers. comm.). Had conflict been managed rather than viewed (by at least some) as a 'barrier', it is possible that research activities may have focussed on other aspects of finch biology or even management issues such as how to manage isolated populations of an endangered species.

In the situation of the development of the mine at Mt Todd, **conflict has been manageable**, if not actually managed. Enormous amounts of time and resources have been expended by the mining company to establish a program to monitor numbers and activity of the Gouldian Finch in the

Yinberrie Hills during the life of the mine. (While a program that was tried to monitor numbers at the mine and control sites was the best in theory, in practice it was not workable because there was no certainty that it would be possible to detect changes in Gouldian Finch numbers.) The program that was adopted monitors annual breeding activity at fixed sites at increasing distances from the mine. As in the past, I will check all nests that are identified as Gouldian Finch nests and those which are difficult to allocate to a species.

So, how did the resolution of **conflict** proceed this far at Mt Todd, compared with the previous example - yet not proceed to completion? In my opinion there has been too little effort to establish constructive dialogue. Exaggerated claims continue to be made on both sides: the mining fraternity may play down potential damage to the environment while the environmentalists claim that the Gouldian Finch is doomed. The situation must be reached in which environmentalists lobby around the table with mining companies to achieve the result that is desired for all parties. The current approach is too costly in terms of time and manpower, and research outcomes may be poorly focussed, resulting in wasted resources.

#### **FUTURE DIRECTIONS**

Mining companies know now that they have an obligation to care for the environment. Until there is certainty that negotiation can proceed, mining companies may suppress environmental issues. They usually have financial resources far beyond those of environmentalists. There must be a partnership in the future so that both groups come out winners as well as the fauna and flora over which there is concern. Environmentalists would do well to cultivate leaders who are skilful, respected negotiators so that they can tap into, help specify and direct, the resources that mining companies apportion to environmental issues.

So what is the future of the Gouldian Finch in the Yinberrie Hills? It is too early to know. Monitoring programs must continue until a trend is clear. Fortunately, the Gouldian Finch demonstrates some plasticity in its breeding behaviour (Tidemann & Lawson in press; pers. obs.) that may enable it to cope with the invasion of a portion of its habitat in the Yinberrie Hills. The mining company however must have a contingency plan in case a decline is observed, particularly now that it appears that this population is genetically isolated from others. One positive feature arising from the focus on the Gouldian Finch is the formation of a recovery team. This team has people from Western Australia and Queensland, where the finch has declined even more severely, together with staff from government and non-government agencies. This team will oversee future research and the formulation and monitoring of recovery plans.

At the other end of the spectrum is the potential effects of pastoralism on the Gouldian Finch. Much of the Gouldian Finch's range is taken up with pastoral activities. The effects of pastoralism are more difficult to detect than those of mining activities. The provision of additional cattle watering points that can be utilized by gramnivores are probably far outweighed by the changes that have occurred in the grass/herb layer (Tidemann 1990). Pastoralists do not have the same environmental management demands made on them as mining companies. This may be short-sighted on the part of the government.

At the moment environmentalists lobby the government in a needling kind of way. Is it worth trying the strategy of negotiating? Who knows; if the environmentalists can master the management of conflict in environmental change, mining companies may well finance the research that is needed to define and manage the interaction between endangered species, pastoralism and other potential threats.

# **ACKNOWLEDGEMENTS**

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# NATIVE PASTURE SPECIES -A LARGELY UNTAPPED RESOURCE FOR THE TABLELANDS OF NSW

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#### INTRODUCTION

Pastures based on native grasses and introduced clovers still dominate many areas of the NSW tablelands, occupying up to 60% of the total area in some regions. Research, commercial experience and recent survey results show that they can be developed to carry up to 90% of the stocking rates of pastures based on introduced grasses and clovers (Wyndham 1992, Munnich et al. 1991, Robinson et al. 1988). In the non-arable, steep and stony areas or on acid soils, they can have a vital role in any sustainable pasture management program. There are several reasons for these conclusions including a progressive decline in soil fertility resulting from reduced fertiliser programs, increases in soil acidity over time with legume based pastures, and local problems with increasing soil salinity and decline in the sown pasture species.

So, with the new century barely six years away let us throw this observation into the ring. If we have any chance of stable and productive pastures after the year 2000, the protection of existing native/perennial grasses, particularly in non-arable areas is paramount. Many pastures based on introduced grasses and clovers alone have not proven to be sustainable over time without regular fertiliser inputs and/or resowing (the only possible exception being Australian phalaris and subterranean clover).

## The Tablelands Pasture Environment

The climate of the tablelands of NSW is highly variable, both between seasons and within seasons. The New England area is characterised by a strongly summer-dominant rainfall pattern with over 60% of the annual rainfall falling between November and February. Rainfall in total varies from 600 to over 1500 mm per year over all the tablelands area.

The rainfall pattern in the Central and Southern Tablelands is characterised by winter dominance and reasonably reliable springs with a patchy storm rainfall pattern over summer and autumn. Further south towards the Victorian border, the rainfall pattern becomes more Mediterranean with reliable winter/early spring rainfall and dry summers.

Tablelands' soils are variable with small areas of high fertility, basalt-derived soils particularly on the Northern Tablelands and to a lesser degree in the Monaro and Southern Tablelands. Most of the soils are based on granite or are of sedimentary origin and range in pH from 4.0 to 5.5 in CaCl<sub>2</sub>. As a general rule, acidity is increasing over time, particularly in old legume-based pastures. There are also small pockets of alkaline soils on the Northern Tablelands and dryland salinity is increasing, particularly in the central and southern areas of NSW - mainly on the valley floors as discharge areas.

Recent surveys (Garden et al. 1993, Munnich et al. 1991) have shown that the year-long green native grasses are widespread and that their abundance appears to be increasing over time. These surveys showed that over 98% of properties had *Danthonia* species present and over 70% had *Microlaena stipoides* present. The presence of Microlaena seem to be related to annual rainfall, its frequency increasing where annual rainfall was greater than 625 mm per annum. Other grasses, which were also widespread and present, were *Poa* and *Stipa* spp. in the Monaro and, in the Central Tablelands, *Bothriochloa* spp. Similar results were obtained in a survey on the Northern Tablelands (Magcale-Macandog and Whalley 1994, Simpson 1993).

These surveys also showed that most landholders (over 80%) are not able to recognise the most useful of the year-long green native grasses, e.g. Microlaena and Danthonia, but the majority are able to recognise the least useful of the native grasses, e.g. Aristida and Stipa spp.

Whilst increasing information confirms that many native grasses are highly acid-soil tolerant, little is known about their tolerance to dryland salinity or alkalinity.

# Uses of Native Pasture Species by Locality

# Southern Tablelands and Slopes

The two most important native grasses present from a commercial viewpoint are the Danthonias and Microlaena. There is a wide variety of Danthonia species present and most paddocks sampled had at least two. The most frequent were *D. pilosa*, *D. racemosa* and *D. monticola* (30 to 50% of paddocks sampled; Munnich *et al.* 1991, Garden *et al.* 1993). The Goulburn survey of native pastures clearly demonstrated that these two grasses are extremely tolerant of acid soils. The average pH of soils carrying native pastures was 4.08 whereas the average pH of the paddocks sown to improved grasses was 4.98 (CaCl, test).

Many native pasture areas in the Central and Southern Tablelands are on the more skeletal, low fertility, acid soils where there has been little history of cultivation or use of herbicides. As such, they are primarily used for grazing, usually on a set stocking basis. Recent work (Simpson 1992) has shown that Microlaena in particular can produce herbage of high quality over the late spring/summer/autumn period with protein levels as high as 20%, and metabolisable energy above 10. Both Danthonia and Microlaena, when green and leafy, had protein levels between 12 and 18%, levels similar to those of pastures based on introduced grasses.

Dry matter production on an annual basis from *D. richardsonii* (Taranna and Hume) and Microlaena has equalled or exceeded the annual dry matter production from phalaris, ryegrass and cocksfoot on a low fertility, acid soil site. These species have not responded to incorporated lime prior to sowing. Herbage quality has been similar to, or better than, introduced grasses under these conditions (Simpson unpub. data).

On a high fertility, non-acid soil site the reverse applies where dry matter production on an annual basis has only been about 30 to 60% of ryegrass, phalaris and cocksfoot (however, Microlaena was the highest yielding grass over the summer/autumn period). Herbage quality has been somewhat similar under high fertility conditions in terms of protein.

The above native grasses seem to be up to five units of digestibility lower than the introduced grasses but their protein levels are similar when compared at the same growth stage. These results are similar to those obtained by Archer and Robinson (1988) in the Northern Tablelands when comparing the year-long green native grasses with introduced grasses under the same conditions.

# Central Tablelands and Slopes

The major species, Danthonia and Microlaena, are also widespread across a wide range of soil types and environments in the Central Tablelands and nearby slopes. However, Bothriochloa is also widespread, particularly in the Mudgee/Rylstone area. Bothriochloa is valuable as a source of quality green leaf when rainfall occurs in the summer/autumn period with protein levels up to 14%.

A pasture improvement program based on fertilisation with superphosphate and aerially oversown with a winter growing legume (sub clover) increased the stocking rates from 2 DSE's per hectare to between 8-10 DSE's per hectare over a 10 year period (Crofts 1989). This approach resulted in an average increase in stocking rates of 5 DSE's per tonne of superphosphate applied (Figure 1).

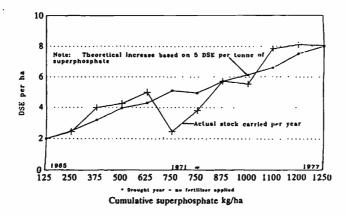


Figure 1. Native pasture development cycle with sub clover and super at Bathurst.

## Northern Tablelands and Slopes

The proportion of pastures on the Northern Tablelands that are based on native grasses has been increasing in recent years. Poor economic conditions in the grazing industries have meant that many landholders have been unwilling or unable to meet the high cost of resowing exotic grasses which generally die out during droughts. These native grasses are mostly warm-season frost susceptible perennials which determine the general structure of the communities (Lodge and Whalley 1989). These pastures also contain a diverse range of other perennial and annual grasses and forbs with up to 100 herbaceous species being present in a single paddock (Lodge and Whalley 1989).

There are about 300 species of grasses that occur on the Northern Tablelands and Slopes (Lodge and Whalley 1989) but seed is available commercially for only a handful of these species. Therefore there is an enormous untapped resource of species for a range of special purposes. Lodge and Whalley (1989) and Whalley (1990) list the basic characteristics of a number of these species but our knowledge of their population biology and how to manage the abundance of the individual species in grazed pastures is abysmally small. There are undoubtedly many species with valuable agronomic characteristics which are largely unknown.

Year-long green perennials are the most valuable of the grasses and the examples which have been studied in the greatest detail are several species of Danthonia and Microlaena. *Microlaena stipoides* is abundant in pastures in the higher, wetter parts of the Northern Tablelands (Magcale-Macandog and Whalley 1994) and often is an important component of improved pastures. There is evidence that different genotypes of Microlaena form stable associations with different species of exotic grasses within a paddock (Magcale-Macandog and Whalley 1991).

White clover is the major legume in grazed pastures on the Northern Tablelands. Sub clover and a number of naturalised clovers or medics also add to the legume component. The abundance of clover in pastures is related to the autumn-spring rainfall pattern, fertiliser application and grazing pressure. If pastures based on native grasses become clover dominant, particularly under favourable seasonal conditions and light grazing pressure, then many of the native grasses will die out. This leaves a severe shortage of feed if the late summer is also dry and the clover dries up and blows away.

# THE MANAGEMENT OF NATIVE SPECIES COMPONENTS

## Whole Farm Management

The tablelands areas of NSW are extremely diverse with respect to topography, aspect, soil type and whether they are arable or not. These factors are usually beyond the control of any one individual owner to change and therefore should be looked at as a collective pool of strengths or weaknesses that can be put together on a whole-farm basis.

The lower slopes and valley floors, which generally include the most naturally sheltered areas with the deepest and most fertile soils, are the areas where productive pastures based on introduced species can be established easily. These pastures should also be persistent. It is in the steep and/or stony infertile hills where the maintenance of ground cover for conservation reasons is important. Many native pasture areas can be developed by a process of evolution, not revolution, with relatively low inputs of fertiliser and legume. The ultimate goal here is to carry up to 5-7 DSE's per hectare over time.

The early days of pasture improvement were mainly based on a replacement approach: native pastures were judged as only being summer growing and providing little or no useful feed in the winter. History has shown that this was not a fair judgement and that the year-long green native pasture species such as Microlaena and Danthonia are capable of being more productive over time given rising soil fertility levels. These species are also extremely tolerant to increasing grazing pressure.

Surely the first step in any whole-farm management planning should be to identify the major perennial grass species present and then relate these species to the farm's goals, soil types present, aspect, and if they are year-long green types, look at their potential to be developed into a more productive pasture over time. Grasses such as Bothriochloa would also have a very useful role to play where there is likely to be a shortage of green quality feed over the summer/autumn period. However

the owner should recognise that this pasture will be inadequate for quality feed in the late autumn/ winter period and may have to be supplemented either by a winter-growing legume or managed accordingly with dry adult stock in good condition.

# **Grass/Clover Ratios**

Native grasses can behave quite differently to some of our introduced grass species with clover dominance; e.g. Danthonia species are generally extremely sensitive to clover dominance, be it white clover or sub clover (Whalley et al. 1978, Whalley 1990). The aim in maintaining Danthonia pastures is to avoid clover dominance by manipulating grazing pressure and fertiliser inputs, depending on seasonal conditions and soil fertility. However some grasses, like Bothriochloa and Microlaena, if undergrazed during their active growth period under favourable conditions, can become very dominant and almost crowd out annual clovers such as subterranean and white clover.

Again, the most important point is for farmers to be able to recognise the major perennial grasses present on their property (most can't, particularly the year-long green native grasses) and be able to alter their management strategies to suit seasonal conditions, the species present, their farm enterprises and goals.

Top dressing (mainly with superphosphate) and introducing a suitable legume (e.g. white and/or subterranean clover) is probably the most common method used to increase the carrying capacity of native grass country. To maintain the year-long green species (wallaby grass and weeping grass), most farmers have developed these areas over a long period (up to 15 years), avoiding clover dominance by applying low fertiliser rates. The change is based on evolution, not revolution. This is the reverse of the system recommended for pastures where introduced grasses and legumes are the dominant species and higher rates of fertiliser are used.

The Goulburn native grass survey showed a steady increase in stocking rates up to 7.5 DSE's/ha in paddocks where legumes were introduced and soil fertility was built up by applying 1 t/ha of superphosphate over an 8 to 15 year period.

Clover composition of a pasture is generally affected by three factors:

- 1. Amount and distribution of rainfall (e.g. a good autumn break followed by a good spring rainfall can lead to subterranean clover dominance). White clover dominance is greatest where high late spring-summer rainfall occurs.
- 2. The amount and frequency of fertiliser increases or decreases the proportion of clover.
- 3. The intensity and frequency of grazing, i.e. increasing or decreasing grazing pressure at critical times (usually at flowering and seeding of the target species).

## Herbicides

Recent research work on the Southern Tablelands has confirmed that there are usable options for landholders that do not destroy the year-long green native perennial grasses present. Established Microlaena can be extremely tolerant of a wide range of herbicides including Roundup (at rates up to 31/ha), Simizine and SpraySeed. Danthonia will tolerate the above herbicides, with the exception of Roundup where it is extremely sensitive to even low rates (e.g. 700 ml/ha will have a destructive effect). Both these grasses are extremely sensitive to Frenock at the registered rate (1 to 21/ha, Keys et al. 1993).

# Grazing Management of Native Grasses to Maintain Desirable or Reduce Undesirable Species

Landholders need to be aware of the major species of native grasses present in their permanent pasture system so as to utilise grazing management which will alter composition over time and achieve gains in productivity.

Varying the timing and length of grazing pressure can favour some pasture species over others. This is especially true where there are significant differences in seasonal growth patterns, flowering and seeding. For example Aristida, which is an undesirable perennial native grass that can cause major

seedhead problems and has low quality food on offer for most of the year, can be reduced by grazing management. Northern Tablelands research showed that heavy grazing when the Aristida is flowering and seeding will progressively weaken it over time. If this system is then followed by light grazing during the following autumn/winter period, the establishment of either year-long green native perennial species (e.g., Danthonia), or annual legumes and annual grasses is encouraged. Oversowing and fertilising a legume, e.g. sub clover and/or white clover, and topdressing will further increase carrying capacity and reduce the dominance of wire grass over time.

Danthonia is very sensitive to clover dominance and heavy grazing to reduce the clover until spring (depending on location and season) will reduce the shading effect on the Danthonia. Late spring rain will allow the Danthonia to seed and recover from grazing.

A similar program can be undertaken where landholders wish to maintain Bothriochloa and avoid clover dominance problems. In this case the grazing could be extended in the spring prior to the Bothriochloa making rapid growth, then allowing the Bothriochloa to seed down over the late summer/autumn period. This would be assisted by allowing soil phosphate levels to fall by either not topdressing for one or two years or by only supering every second or third year.

# **Species Diversity**

Rainfall patterns through the tablelands area of NSW fluctuate dramatically, both in annual amounts and in timing. Most of this area is a watershed for the major urban areas (Wollongong, Sydney and Newcastle) and the clean water harvested has been estimated to be worth at least \$200 per hectare. An important goal for sustainable pastures then is to maintain as close to 100% ground cover as possible. It is unlikely that any one species will be perfect in all characteristics for both grazing and conservation purposes. However, animal performance will be directly related to having green leaf on offer, if possible, for 12 months of the year.

Most of the surveys carried out through the tablelands of NSW have highlighted the incredible diversity of species present in native pastures. This diversity includes winter and summer growing species (both annual and perennial) and changes in their composition with season, fertilisation and grazing pressure. We do not know the significance of many of the minor species compared to major species but, at this stage, it would be unwise to ignore them as they may assist in maintaining pasture in a productive and sustainable equilibrium (Leigh 1990, Whalley 1990).

Until recently, the forage production of native grasses as a grazing or conservation resource had been taken for granted. Native grasses generally received little attention or inputs and were regarded as something to be exploited wherever possible. Their vital role in protecting the soil and providing ground cover and their incredible drought persistence went largely unacknowledged. In addition, native grasses were often treated unfairly as if they all had similar production, palatability and forage values. One possible explanation for this may be that the individual species are difficult to recognise, particularly the low growing prostrate year-long green species, and many people are less able to recognise the most useful of these species.

Recent work has highlighted how adaptable, persistent and productive some of these native grasses can be with the changing management environment. Much more work needs to be carried out.

# Land Stabilisation and Revegetation

Many of the perennial native grasses could prove ideally suited for land stabilisation and revegetation programs. Some species provide year-long ground cover and effective weed control once established. They are adapted to a diversity of environments and require low inputs and maintenance. Depending on species selected they may well prove to be fire retardant and, to some people, aesthetically attractive (Lodder *et al.* 1986).

Potential species which may have a role in these areas include *Microlaena stipoides*, *Danthonia* and *Themeda* spp., and *Bothriochloa macra*. Current research and development programs on the slopes (3-500 mm rainfall) may well widen this list. The CSIRO have a program of selecting and evaluating Danthonia and Themeda for roadside revegetation. Hume Wallaby Grass (a selection from *Danthonia richardsonii*) should be commercially available shortly. It has performed extremely well on the

Southern Tablelands over the past five years when compared to traditional exotic lawn grasses, and also on a low fertility acid soil site at Goulburn. In 1989 the CSIRO commenced a selection program on *Themeda triandra* and have selected a low prostrate growth type from alpine areas which will soon be released for seed production (Sindel 1993). A low growing, dense variety of Microlaena is being developed for low maintenance areas by the University of New England. This variety will be released once plant variety rights registration has been completed. Current research programs are looking at refining the basic agronomic requirements for successful establishment and management of Microlaena, Danthonia and Themeda.

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#### ECOLOGY OF GRAZED TROPICAL TALLGRASS RANGELANDS IN NORTHERN AUSTRALIA

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#### **ABSTRACT**

The tropical tallgrass rangelands occur across the top of Australia from the Kimberleys to Bowen on the east coast. Throughout most of the zone, rainfall varies from 500 to 1000 mm with 80-95% falling in summer. Temperatures are high and are seldom limiting for pasture growth when water is available. Beef cattle grazing is the most widespread land use. Increases in grazing pressure have been associated with the loss of perennial grasses, woody weed invasion, and increased runoff and soil loss in some areas. The population dynamics, diet selection patterns and defoliation responses of the perennial grasses are outlined and ways this understanding can be incorporated into management are presented. The perennial grasses are sensitive to defoliation (particularly in the north-west) and can only be lightly utilised, although resting during the early wet season, when they are particularly sensitive, may enable utilisation during the rest of the year to be increased. Fire can be used to improve animal distribution and reduce patch formation. Sown pastures and tree clearing can be used to increase carrying capacity but careful consideration needs to be given to any tree clearing to prevent problems experienced elsewhere occurring in the region.

## INTRODUCTION

The tropical and monsoonal tallgrass pastures (Mott *et al.* 1985) occur in northern Australia from Derby in the West Kimberley, though the Top End of the Northern Territory and Cape York Peninsula, to Bowen on the east coast. The vegetation (savanna) is an open woodland with eucalypts usually dominant in the tree layer and annual or perennial tussock grasses dominant in the ground layer. In this paper we briefly describe the annual pasture systems and then examine the perennial systems in detail using data from Katherine in the Northern Territory and from the Townsville-Charters Towers region of north-eastern Queensland. For this paper, the perennial systems include the ribbon grass (*Chrysopogon fallax*), plume sorghum (*Sorghum plumosum*) and black spear grass (*Heteropogon contortus*) pastures of Tothill and Gillies (1992).

## **ENVIRONMENT**

Throughout most of the zone rainfall varies from 500 to 1000 mm. Seasonality is greatest in the west where over 90% of the annual rainfall falls in the summer months (October-March). Reliability is also highest in the west with variability (mean deviation as a percentage of the mean) of annual rainfall increasing from less than 20% in the Top End of the Northern Territory to 30% in eastern Queensland. This variability is also apparent in the severity of the dry season; in the west the dry seasons are predictably dry but in the east significant falls can occur which can result in pasture growth and high quality feed.

Temperatures are high throughout the region and are seldom limiting for pasture growth during the period when water is available, especially in the west. Since temperatures are high the growing season starts suddenly with the first storms rather than by gradually warming temperatures as occurs in south-east Queensland (Mott *et al.* 1985). Frosts are rare but do occur in inland areas in the east.

The combination of temperatures and rainfall produces a hot, "wet" season and a warm "dry" season. However the reliability and severity of these seasons varies both between years and between locations. This is illustrated in Fig. 1 where the frequency distribution of "green" weeks during the year is shown for Katherine and Woodstock (from McCown 1982).

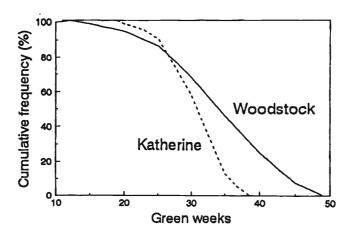


Fig. 1. Cumulative frequency distribution of green weeks during the year at Katherine and Woodstock, near Townsville (from McCown 1982).

Soils are mostly poor, particularly in the west, and there are only limited areas of fertile soils. The combination of low soil nutrients and good growing conditions (high temperatures, radiation and available water) during the wet season leads to the production of low quality herbage by the end of the wet season. The quality of this material continues to decline throughout the dry season and provides the major limitation to animal production in the region.

Compared to the temperate and arid rangelands, the tropical tallgrass areas have a reliable seasonal rainfall of greater magnitude, an absence of cold periods (Table 1), greater limitation of plant growth by nutrients rather than water, and a nutrient rather than biomass limitation to animal production.

Table 1. Climatic data for selected locations in the tropical tallgrass region (Katherine and Charters Towers) and other rangeland areas of Australia (Anon. 1988). The temperature value is the average maximum temperature during July. The number in brackets is the summer rainfall as a percentage of the annual total.

Location	Rainfall (mm)			Temperature (°C)	
	Summer (Oct-Mar)	Winter	Total		
Katherine	924	(95)	48	972	29.8
Charters Towers	524	(80)	134	658	24.4
Broken Hill	110	(48)	118	<b>22</b> 8	15.7
Cobar	192	(55)	160	352	16.2
Carnarvon	64	(27)	170	234	22.0
Kalgoorlie	117	(46)	139	256	16.5
Alice Springs	200	(70)	85	285	19.4

#### **ANNUAL PASTURE SYSTEMS**

Annual pasture systems are important because of their large extent across the northern part of the region (from the Kimberleys to Cape York Peninsula), their dominance in the understorey (dense swards up to 2m tall), and their impact on land management, especially via fire (Mott and Andrew 1985; Morton and Andrew 1987). In the north-west the dominant species are annual *Sorghum* spp. (whose taxonomy is quite complex; Lazarides *et al.* 1991) which occur on both sandy/gravelly soils (e.g. *Sorghum intrans*) and on cracking clay soils. On Cape York, *Schizachyrium fragile* is an important species.

These Sorghum species are ecologically interesting because they are annuals whose soil seed banks are exhausted early in the growing season and replenished at seed fall, making them easy to eliminate

by wet season fire. They have low nutrient status (Cook and Andrew 1991) and do not withstand grazing. Thus the annual pasture systems are not useful for beef production in their natural state but some areas of improved pasture have been established after removing the native species (Mott *et al.* 1985). However, they are significant for the management of tropical savannas e.g. Kakadu National Park comprises mostly annual Sorghum areas.

#### LAND USE

The predominant land use has been extensive beef cattle grazing which commenced in the 1860's in the east and spread to the remainder by the end of the nineteenth century. Cattle grazing remains the most widespread land use but increasing areas are being used by aboriginal communities, and for conservation and tourism. Mining is very important on an income basis but much less so on an area basis. There is only a small local market for beef and the industry has always been export oriented, either to elsewhere in Australia or overseas. For much of the last 30 years the US market has been the major outlet but in recent years shipment of live animals to Asia has increased dramatically.

The beef industry was initially based on British breed animals and light stocking rates to enable the maximum diet selection from the generally low quality herbage and minimise effects of drought years. This has changed markedly in the past 20 to 30 years, particularly in the east. There has been a marked increase in the proportion of *Bos indicus* cattle, increased use of supplementary feeding to minimise nutrient deficiencies in the herbage, confinement for animal disease testing, increased numbers during 1970s when prices were low, and confinement for shipping during the wet season. The combined effects of these changes has been increased grazing pressure on the pastures.

#### **PROBLEMS**

With the increased grazing pressure, there has been a widespread decline in the density of the perennial tussock grasses. The problem appears to be more widespread in the north-east (Tothill and Gillies 1992) where a decade of generally below-average wet season rainfall during the 1980s exacerbated the losses due to overutilisation. In the north-west the perennial grasses growing on infertile soils are particularly sensitive to defoliation and losses can occur at low levels of utilisation (Fig. 2). Early reports by Arndt and Norman (1959) showed the potential for rapid decline of *Themeda triandra* pastures especially under drought conditions. In a comprehensive grazing experiment involving stocking rates, tree killing, fertiliser and oversowing *Stylosanthes* spp., Winter *et al.* (1989a) found that as stocking rates increased there was a rapid decrease in the perennial grasses with *Sorghum plumosum* and *Themeda triandra* being replaced by ephemeral species or in severe cases with bare, scalded ground.

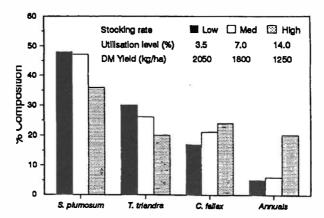


Fig 2. The influence of stocking rate on the composition of tallgrass pasture at Katherine. Measurements were made after 4 years grazing (from Arndt and Norman 1959).

The perennial grasses provide the bulk of the herbage and are also particularly important for providing ground cover at the start of the wet season when high intensity storms may cause severe erosion on unprotected soil. Because of this, emphasis has been placed on their growth and survival and details of the population dynamics are examined in a later section.

The increase in grazing pressure is implicated in the increase in woody weeds, both native and exotic. Increased herbage consumption by grazing animals means less fuel and fewer, cooler, and more patchy fires - one of the main controls on woody vegetation. Less grass also means less competition with woody plant seedlings. The relative importance of these two mechanisms for woody weed control is currently being examined (Brown *et al.* 1993).

The reduced herbage also results in lower ground cover (Scanlan and McIvor 1993) with increases in runoff and soil loss (Table 2), especially when cover levels fall below 40% (McIvor *et al.* 1994), and soil surface sealing (Mott *et al.* 1979; Bridge *et al.* 1983). Once the surface has sealed infiltration is poor, grass re-establishment is difficult, and recruitment is slow (Mott, unpubl. data).

Table 2. Relative soil movement from experimental treatments (tree killing, pasture sowing, stocking rate) at Cardigan, near Charters Towers. Soil movement on lightly grazed native woodland = 100. (From McIvor *et al.* 1994).

Treatment	Soil movement
Live trees, native pasture, stocking rate = 1 beast/10 ha	100
Live trees, native pasture, stocking rate = 1 beast/2 ha	289
Killed trees, native pasture, stocking rate = 1 beast/2 ha	81
Killed trees, sown pasture, stocking rate = 1 beast/2 ha	17

## PLANT GROWTH

In the north-west, the reliable, highly seasonal rainfall means water is usually available during the wet season. Temperatures are rarely limiting during this period and the major constraint to plant growth is available nutrients, especially during the latter part of the wet season (Mott*et al.* 1985). This results in consistent production between years (e.g. Manbulloo in Table 3) but with good growing conditions and limited nutrients, herbage quality is low as nutrients are diluted and levels continue to decline through the long dry season. In contrast, in the north-east, rainfall varies much more between years and also during the wet season so that dry periods are common during the growing season. Temperatures may also be limiting late in the growing season. In years with favourable weather, soil nutrients become limiting. All these combine to give much more variation in herbage supply between years (e.g. Hillgrove in Table 3). Quality also varies. In years with extended wet seasons or dry season rainfall, green material is present for long periods.

Table 3. Presentation yields (kg/ha) of the herbaceous layer in lightly grazed woodlands at Hillgrove (near Charters Towers) and Manbulloo (near Katherine). Stocking rates were 1 beast per 10 and 14 ha respectively.

	Year	Hillgrove	Manbulloo
	1982	1280	1620
	1983	2060	2240
	1984	3650	2020
	1985	3060	1970
	1986	2700	1490
	1987	2130	1800
	1988	800	1720
	1989	2490	2040
Mean		2270	1860
S.D.		920	250
C.V. (%)		40.5	13.4

## POPULATION DYNAMICS OF THE PERENNIAL GRASSES

#### **Seed Production**

Seed production by most grasses is modest. For example, seed production from ungrazed *Themeda triandra* at Katherine was 150/m² (Mott *et al.* 1985) while Howden (1988) measured seed numbers (average over 3 years) in dense, ungrazed swards at Lansdown near Townsville of 4600/m² for *Heteropogon contortus* and 1200/m² for *Themeda triandra*. This contrasted with 63100/m² for the naturalised grass, *Bothriochloa pertusa*. In another study at Lansdown (McIvor *et al.*, unpubl. data), seedheads were counted in grazed swards (Table 4). The small numbers of seedheads of the native perennials and their sensitivity to grazing are apparent.

Table 4. The effect of stocking rate on seedhead production  $(no/m^2)$  of perennial grasses in a mixed pasture at Lansdown, near Townsville (McIvor *et al.*, unpubl. data).

Species	Stocki	Stocking rate (animals/ha)		
	0.3	0.6	0.9	
Themeda triandra	1.3	0.4	0.2	
Heteropogon contortus	3.8	1.3	0.2	
Chrysopogon fallax	1.3	0.4	0.4	
Bothriochloa pertusa	13.9	17.1	17.3	

#### Seed Banks

Studies with a number of tropical grasses, both annual and perennial, native and introduced, have shown that seeds are dormant at seed fall (Mott 1978; Andrew and Mott 1983; Hacker 1984; Mott and Andrew 1985; Hacker 1989; Hacker and Ratcliff 1989). Dormancy is broken by exposure to dry heat, and temperatures on the soil surface during the dry season ensure dormancy is broken before the following wet season. There is no long term store of dormant seed as all seed either germinates or dies during the wet season - Mott and Andrew (1985) found no viable seed of Themeda triandra in soil during the wet season prior to seed input and McIvor and Gardener (1991) measured only 0 and 2% survival of Heteropogon contortus seeds between the start and middle of the wet season in 2 years. Seed numbers of these grasses at the start of the wet season reflect the seed set the previous year and survival over the dry season. Measurements at this time have shown that even if total seed numbers are high, the numbers of seeds of native perennial tussock grasses are low. In a study of 20 native pasture communities near Collinsville, McIvor and Gardener (1994) found on average there were 4000 seeds/m<sup>2</sup> but of these only 170 were native grasses (Bothriochloa pertusa contributed 620). In a lightly grazed pasture (90% native perennial grass) at Cardigan near Charters Towers total seed numbers varied between 460 and 1340/m² over five years including 60 to 480 perennial grass seeds. Mott and Andrew (1985) measured only 8 seeds/m<sup>2</sup> of Themeda triandra in a pasture at Katherine even though it dominated the pasture.

## Germination/establishment

Since dormancy is largely broken during the dry season most germination (70-80% of total for the year) occurs on the first major rainfall event of the wet season (Stocker and Sturtz 1966; Torssell and McKeon 1976; Mott 1978, 1980; Andrew and Mott 1983; McIvor and Gardener 1991). Seedling numbers may be high but survival is often low; Mott and Andrew (1985) recorded 20% survival over the first wet season for *Themeda triandra* but all plants died by the end of the next wet season.

# Longevity

Individual plants of the major perennial grasses can live more than 8 years at Katherine but tussocks are much shorter lived in south-east Queensland (Mott  $et\,al.$  1985). The survival of perennial grasses in  $10\,x\,10$  cm quadrats has been followed at Hillgrove and Cardigan for a number of years (Fig. 3). Survival was much greater in *Chrysopogon fallax* than *Heteropogon contortus*; after 5 years *Chrysopogon fallax* continued to occupy 40-50% of the quadrats where it was originally present, compared to less than 10% for *Heteropogon contortus*.

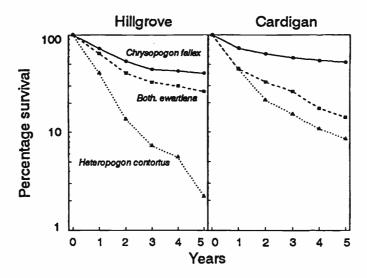


Fig. 3. Survival of perennial grasses in grazed  $10 \times 10$  cm quadrats at Hillgrove and Cardigan, near Charters Towers (McIvor and Gardener, unpubl. data).

#### **DEFOLIATION AND DIET SELECTION PATTERNS**

The effect of defoliation on plant survival depends on the response of the plant to defoliation, and the level of defoliation it is placed under through diet selection processes, i.e. a plant that is sensitive to defoliation may survive if it is not preferred by cattle.

In a detailed series of studies to quantify mechanisms controlling grazing sensitivity in perennial grasses (Mott et al. 1988), it was found that under the growing conditions at the start of the wet season in the north-west, there was synchrony of tiller formation. Under these conditions the majority of tillers in *Themeda triandra* commenced growing at the same time. If these were subsequently defoliated and killed there were no more tillers to replace them and the plants died (Mott et al. 1992). Both this study and one by Hodgkinson et al. (1989), found that the main reason for the sensitivity of *Themeda triandra* to grazing was its poor ability to maintain positive carbon gain after defoliation due to low photosynthetic rate, low specific leaf area and a large proportion of sheath material after cutting.

Patterns of selection and defoliation vary both spatially and temporally. In a study of pastures where alternate halves were burnt each year, Andrew (1986a) found most quadrats in the recently burnt half were grazed when growth was new and in short supply so that both percentage defoliation and frequency of grazing were high. As growth became more abundant animals grazed a smaller and smaller total area and mean percentage defoliation fell until growth ceased. Animals then began to extend existing patches. Among the perennial grasses, *Themeda triandra* was the most selected, *Sehima nervosum* and *Sorghum plumosum* were neither selected nor rejected, and *Chrysopogon fallax* was generally rejected. Cattle grazed least selectively during the early wet season and then became increasingly selective so that the difference between species was maximal at the end of the wet season and then declined during the dry season (Andrew 1986b).

As individual *Themeda triandra* plants are lost from the system through overutilisation, it's contribution to pasture biomass declines and extra diet selection pressure is placed on the remaining *Themeda triandra* plants (Fig. 4) placing them at even greater risk of being killed. Less palatable perennials such as *Chrysopogon fallax* become more preferred as the *Themeda triandra* population declines.

## INTEGRATION OF ECOLOGICAL UNDERSTANDING AND MANAGEMENT

Since deleterious changes have been associated with increased grazing pressure it is essential that grazing pressure is managed and utilisation levels are kept within the tolerance of the community. Grazing pressure can be reduced by either increasing the amount of feed grown, or reducing the amount of feed consumed.

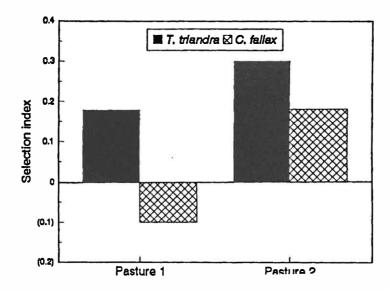


Fig. 4. Changes in diet selection of perennial grass species with change in botanical composition. A selection index of 0 indicates no selection; a positive value indicates selection for that species. Proportions of *Themeda triandra* and *Chrysopogon fallax* in the pastures were 50% and 35% for Pasture 1 and 16% and 42% for Pasture 2 (Ash, unpubl. data).

## Stocking Rates and Pasture Spelling

Choosing appropriate stocking rates is a key management decision in any animal production system (Humphreys 1991). The tallgrass pastures are sensitive to grazing and can only tolerate low levels of utilisation. Studies of subtropical tallgrass pastures in south-east Queensland suggest these pastures can tolerate 30% utilisation (McKeon *et al.* 1990) but this is much too high for *Themeda triandra* pastures on infertile soils at Katherine where calculations suggest only 10-15% utilisation can be tolerated under year-long grazing. Since the grasses are most sensitive to grazing during the early wet season (Mott 1987), careful control of grazing at this time should give benefits. Studies have recently commenced at Manbulloo to test the response to early wet season spelling in relation to stocking rate during the remainder of the year.

## **Fire**

Fire can be used to improve the distribution of grazing animals (Andrew 1986a) and prevent/minimise the formation of patches. Animal production is also higher as animals have access to higher quality, post-burn feed (Winter 1987). Fire also has a role in woody weed control and it will be an important part of management in the future.

Light utilisation (average of 12%) and burning of half a paddock in alternate years has been used at Manbulloo for 18 years. The trends in perennial grass content of these pastures are shown in Fig. 5. These results demonstrate that the perennial grasses can be maintained in these systems with this management regime.

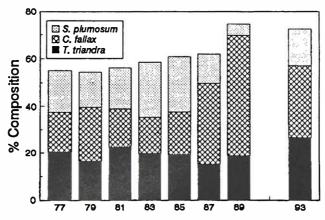


Fig. 5. Changes in the perennial grass content of a lightly grazed and burnt tallgrass pasture at Manbulloo, near Katherine (Ash, unpubl. data).

#### **Sown Pastures**

Due to the relative reliability and amount of the seasonal rainfall, legume-based sown pastures are an option in the tropical tallgrass zone. This is in contrast to the lower rainfall rangelands elsewhere where reliability of establishment is so low that sown pastures can only be considered for special purposes. The legumes allow the nitrogen limitation to be reduced and as sown pastures can tolerate higher stocking rates than native pastures, they have a role in providing more and better quality feed, providing ground cover to maintain land stability, and with their higher carrying capacity enable better stock control and reduced handling costs. The use of small areas of improved, high carrying capacity country in the early wet season would allow much larger areas of native pasture to be spelled at this critical time when they are sensitive to defoliation.

## Tree Clearing

Trees compete with pastures for nutrients and water (light is unlikely to be of critical importance in these open woodlands). The grass response of tree clearing depends on both the soil fertility and distribution of rainfall during the wet season. When rainfall is high and well distributed, and water is continuously available and non-limiting, there is little competition between trees and grasses for water (Mott *et al.* 1985). However tree killing can make more nutrients available and increase grass production (Winter *et al.* 1989b). Where rainfall is lower or where there are interspersed wet and dry periods during the wet season, trees do compete with grasses for water. Under these conditions response to tree killing will depend on soil fertility and will be higher on fertile soils. The variation in herbage response to tree killing between years is illustrated in Fig. 6. The water index is a measure of the water available for growth (0 = no water available, 1.0 = water not limiting). In 1988 growing conditions were very poor and the herbage response was large. In contrast in 1991, there was a long period when water was continuously available and the herbage response was small. Growing conditions and responses were intermediate in 1989. Given the geographical distribution of rainfall and soil fertility, tree clearing responses will be least in the west and greatest in the east (and even higher in south-east Queensland) (Scanlan and McKeon 1993).

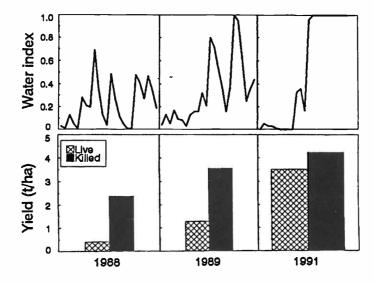


Fig. 6. Weekly water availability index values and the herbage response to tree killing in contrasting years at Hillgrove, near Charters Towers (McIvor and Gardener, unpubl. data).

Although tree clearing increases herbage production and carrying capacity, there are also real and potential problems with tree clearing - regrowth of the original vegetation, invasion by woody weeds, potential salinity, erosion with mechanical clearing, loss of wildlife habitat, and deleterious soil changes associated with higher soil temperatures. Tree clearing disturbs the hydrological cycle that is in balance in the native woodland and can lead to salt accumulation in lower parts of the landscape (Williams and Chartres 1991). Dryland salinity problems are most extensive in Western Australia and Victoria and careful consideration should be given to any tree clearing in northern Australia to prevent similar problems occurring, although Burrows (1991a, b) has pointed out that some of the causal factors present in southern Australia do not occur in northern Australia.

## **Decision Support Systems**

Decision support systems are being constructed to enable managers to assess the impacts (both biological and economic) of management decisions. For example, the HERDECON module of RANGEPACK enables the biological and economic consequences of management decisions to be evaluated at the property level (Stafford Smith and Foran 1988); LANDASSESS is designed to assess the current state of grazing lands, risks of alternative management strategies, and costs and benefits of changes to the state of the land (Bellamy *et al.* 1993); and GRASSMAN compares the impact of management (tree clearing strategies, stocking rate, burning) on animal production and profitability from woodlands (Scanlan and McKeon 1990).

## OTHER USES

There have been changes in land use and these will continue, probably at an increasing pace. Aboriginal use, conservation in National Parks and tourism are all increasing in area and activity. Whether management is for beef production or other uses, it must be ecologically based. Often only simple, low cost, extensive management practices can be implemented and it is essential these be made with knowledge of their interactions with uncontrollable environmental influences.

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## **EROSION PROCESSES AT A REGIONAL SCALE**

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#### **ABSTRACT**

Wind erosion is less well understood than water erosion, largely because of measurement difficulties. Meteorological records provide a broadscale measure of dust storm occurrence and event-based studies can estimate sediment loads in tonnes, but the most meaningful measure is soil loss rate (t/ha or mm depth). Monitoring at Charleville shows that soil loss rates during 1987-1990 were up to 80% of water erosion rates. Water also acts as a supplier of sediment to wind erosion.

## INTRODUCTION

Soil erosion is acknowledged to be an important agent in the degradation of Australian rangelands, but the role of water erosion is better understood than that of wind erosion. In addition, there are important interactions between the two which have received little attention.

This paper describes different approaches to wind erosion measurement, compares water and wind erosion rates, and describes interactions between these two agents of soil erosion.

## WIND EROSION MEASUREMENTS

#### Assessment of Wind Eroded Land

Limited quantitative data are available on wind erosion rates in rangelands largely because of measurement difficulties. Field assessments of wind eroded land are difficult because the evidence is usually subtle. A number of maps of soil erosion in Australia exist and while there is some agreement on the major erosion hazard areas, there are also considerable differences depending upon the definitions and assessment techniques used, as well as the time of survey. At a more local level, the conceptual models of Pickup and colleagues (summarised in Pickup 1989), including erosion cell mosaics and grazing gradients, provide useful ways of dealing with the broadscale aspects of land degradation using remote sensing techniques. The potential of these approaches for wind erosion assessment is worth consideration.

## Field Measurements

Field measurements of wind erosion processes in rangelands are also difficult because, unlike water erosion, winds are not channelised or confined within catchment boundaries, and can operate at a wide range of scales; from the local removal of soil by willy willies, to soil removal over large areas in dust storms. These features make both collection of wind eroded sediments, and the identification of source areas, difficult.

# 1. Records of dust storms and related events

Probably the best broad scale record of wind erosion processes is available in meteorological records of dust storms and related events. After 1960, detailed meteorological records can be used to map the extent of dust storm occurrence (McTainsh and Pitblado 1987), which is largely confined to semi-arid and arid regions (<400 mm rainfall).

Although the spatial resolution of these meteorological data is low (154 stations throughout Australia) and the reliability of some of the records questionable, the pattern is generally consistent with other assessments of wind erosion (McTainsh and Leys 1993). Furthermore, at stations like Charleville with reliable records, good relationships exist between dust storm frequencies and more direct measures of dust concentrations by high volume air sampler (r²=0.58). These records of dust storm frequency have also been used to calibrate broadscale models of wind erosion (summary in McTainsh and Leys 1993).

# 2. Estimates of sediment loads within dust storms

Recent studies of large dust storm events indicate that these carry extremely large quantities of sediment. Raupach *et al.* (1994) estimate that the Melbourne dust storm in February 1983 carried 1-2 Mt of dust (in contrast to an earlier estimate by the Victorian Department of Conservation, Forests and Lands of 140,000t). Knight *et al.* (1994) estimate that a dust event originating in the Birdsville area of the Simpson Desert in December, 1987 transported up to 3.3Mt of dust off the Queensland coast.

## WIND AND WATER EROSION COMPARISONS AT CHARLEVILLE

#### Soil Loss Rates

The most meaningful measures of wind erosion rate are; soil loss per unit area of land (t/ha/yr) or depth of sediment removed (mm/yr), but because of the multi-directional nature of wind erosion, this requires an identifiable source area. An experiment was set up at the QDPI Croxdale Research Station, 20 km west of Charleville to measure soil loss rates from both wind and water erosion (Miles 1993).

Measurements were made during 1987-1990 using wind vane samplers slightly modified after the design of Fryear (1986) and calibrated by Shao *et al.* (1993). These samplers were set up in two small monitored catchments for measuring soil erosion rates by water (Miles 1993), which provided the opportunity to compare soil erosion rates by water and wind. Details of the method for measuring wind erosion rates are described by McTainsh *et al.* (1994 - in preparation).

Wind erosion removed 0.28mm/yr (or 80%) of the material removed by water erosion (0.35mm/yr). As the wind vane samplers may underestimate sediment fluxes, particularly on fine textured soils, the soil loss by wind could be an underestimate. On the other hand, some of the saltation material trapped may not be removed from the study area therefore leading to an overestimate of wind erosion. An independent estimate of the relative roles of these two agents of erosion is available from the radioactive-isotope caesium-137 (Cs<sup>137</sup>) record. According to the Cs<sup>137</sup> method, total soil erosion losses over the last 40 years in the mulga lands were 30-50mm (or 0.75-1.25mm/yr) (Miles 1993), whereas the total annual soil loss (water plus wind) during 1987-1990 was only 0.63mm. As the 1987-1990 sampling period was a period of relatively low dust storm occurrence, soil loss by wind in the long term is likely to have been significantly higher than by water.

## **Nutrient Decline**

Wind erosion is a more particle-size selective process than water erosion, which removes soil *en masse*. This winnowing effect of wind can significantly reduce the productive capacity of soils by the removal of fine particles and organic matter.

The nutrient status of samples of wind and water eroded sediments collected over three years at Charleville is shown in Table 1.

Table 1. Comparison of the nutrient status of wind and water eroded sediments with the soil surface on the same site in the mulga lands of SW Queensland.

Eroded Sediment	Total N (%)	Avail P (ppm)	K (me %)	Org C (%)
Water	0.08	8.97	0.33	1.45
Wind	0.24	71.05	8.3	3.1
Soil	0.09	17	1.01	1.9

The water eroded sediments have nutrient concentrations less than or equal to the source soil, whereas the wind eroded sediments are enriched in all nutrients, which demonstrates the highly selective nature of the process. Therefore, even in situations where wind erosion removes less material than water, the decline in soil productivity resulting from wind erosion may be greater. These effects are accentuated because soil nutrient status and productivity are tied closely to the soil organic matter and as Table 1 shows, the organic carbon of wind eroded sediments is also highly enriched.

## Overgrazing and Soil Degradation

Vegetation removal by overgrazing exposes the soil surface to erosion (and trampling further increases soil erodibility) leading to soil loss and reduction in soil productivity. Vegetation removal breaks the cycle of nutrients between plants and soil. With the loss of organic matter, soil surface aggregates slake, sealing the soil surface and increasing the potential for water erosion. If overgrazing continues the soil degrades to a point where major inputs are required to return the soils to their original productive capacity. The current cost of such inputs grossly exceeds the returns from the land. The maintenance of ground cover through conservative use minimises erosion and maintains the nutrient cycling process and sustains the land use.

# INTERACTIONS BETWEEN WIND AND WATER EROSION PROCESSES

Wind and water erosion are generally considered to occur in separate areas and as a result interrelationships between the two are seldom considered. While it is true that water erosion is more prevalent on the coast and wind erosion is more active inland, water and wind erosion do operate together in arid environments. Water erosion often acts as the supplier of sediment to wind erosion, by concentrating erodible sediments. This relationship operates at a great range of scales; from the local to the continental scale.

At the local scale, water-wind interactions are described by portable wind tunnel simulation of erosion (Miles *et al.* 1994 - in preparation). Local wind erosion events occur in "time windows" following major rainfall events, when sediments recently washed into local depressions, are entrained by wind before a protective vegetation cover has developed. There may be potential to describe these process interactions using Pickup's (1985) concept of erosion cell mosaics.

At a continental scale internally-draining river systems feed sediment to dunefields and dust pathways, a relationship which Australia shares with the Saharan Africa (McTainsh 1985).

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# MODELLING UTILISATION RATES IN THE BLACK SPEARGRASS ZONE OF QUEENSLAND

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#### **ABSTRACT**

We used the concept of utilisation (amount eaten/amount grown) to evaluate different scales of information on grazing land use (defoliation trials, grazing trials, property stocking rates, local consensus data and regional stocking rate statistics). The analysis of defoliation and grazing trials shows the principles and quantitative relationships for simulation models that allow sustainable utilisation rates to be determined. The analysis of property and local consensus stocking rate data shows less variability in utilisation rates than in actual stocking rates, suggesting that, unlike stocking rates, safe utilisation rates can be extrapolated across a wide range of land resource units and climates. There was at least a two-fold variation in "safe" utilisation (10-20%). This could: (1) indicate that there is a range of "safe" pasture use; or (2) that a more accurate estimate of critical utilisation rate is required.

## INTRODUCTION

The recent review on the condition of grazing lands in northern Australia (Tothill and Gillies 1992) concludes "there is widespread deterioration in most pasture communities in Queensland; this is indicated by undesirable changes in pasture composition and soil surface characteristics such as cover and organic matter content". Deterioration was thought to be related to increased grazing pressure resulting from below average rainfall in the 1980s, substantial buildup of livestock numbers in the 1970s and possibly improved husbandry practices allowing stock to survive stress periods.

To ensure sustainable use of these lands, high priority was given to "establishing guidelines for safe stocking strategies". A major issue is the determination of a "long-term safe stocking rate", that is a stocking rate which "will maintain the pasture resource in a desirable and productive condition". Safe stocking strategies should also address the problems of:

- \* spatial variability in pasture resources and grazing patterns;
- \* decade-to-decade variation in rainfall:
- the varying sensitivities of pasture communities to inevitable periods of overgrazing;
- varying resilience of pasture species to such stresses;
- \* the possible options of strategic spelling to maintain desired pasture composition (Tothill and Gillies 1992); and
- \* the high likelihood of climate change (McKeon et al., 1990).

# What Can Grazing Land Science Contribute?

The review of Tothill and Gillies (1992) highlights the major need for a rational approach to estimating safe stocking rates. There are many approaches to, and influences on, the stocking rate problem (practical experience, local consensus data, commonsense, grazing trials, state-and-transition models, market forces and simulation modelling). The major issues in comparing approaches are:

participation of graziers; ease of use; extrapolation to other properties; and capacity to adapt to climate change. The modelling approach attempts to overcome the major disadvantages of the other approaches, i.e. the difficulty of extrapolating to different land resource units and climates.

#### SYSTEMS APPROACH TO CALCULATING STOCKING RATE

Pasture growth is the major source of energy and nutrients required for animal growth. The ratio of removal by grazing to the amount grown is often termed "utilisation". Utilisation provides an index of the grazing pressure on the soil/plant system and sets some conceptual bounds (at least between 0 and 100%) on how much can be eaten by domestic and feral stock, macropods and insects. This concept of utilisation allows the different approaches and different pasture communities to be compared with a common basis, i.e. % eaten of amount grown.

Utilisation as used here is calculated over the growing period. This is fundamentally different from the utilisation of a known quantity of forage after it has been produced (as used in western Queensland). The more unreliable growth is, the more emphasis should be placed on use of pasture once it has been produced. This change in emphasis is paralleled by a need for greater flexibility in stock numbers and an increased importance of a tactical approach to stocking rates rather than a strategic approach which may be applicable in more mesic environments.

# Animal intake by domestic stock can be estimated either as:

- (1) a potential intake assuming quantity and quality of pasture are not limiting intake, e.g. a 450-550 kg liveweight adult beast eats about 9-10 kg dry matter per day, a dry sheep equivalent eats about 400 kg per year, (SCA 1990 p. 223), or as
- (2) an *actual intake* reflecting quantity and quality limits. For dry cattle, actual intake can be calculated from known liveweight gain and liveweight, e.g. Minson and McDonald (1987). Intake per head usually declines with increasing utilisation. Thus the use of measured liveweight gain to calculate intake includes this feedback when actual utilisation is calculated. Ideally, intake by other herbivores, especially macropods and feral stock, should be included. Estimates of dry matter intake are likely to vary depending on information available (e.g. SCA 1990), therefore comparison of utilisation rates will require a standardised procedure which as yet remains to be established.

## Pasture Growth

Actual pasture growth can be estimated by measuring the change in known standing pasture yields (plus calculated or measured removal by grazing or mowing) providing detachment rates are known. This is rarely the case in grazed unburnt pastures and hence estimates are more accurately made from situations either when detachment is low (e.g. season following burning) or when there is complete disappearance of carryover dry matter from previous years. An alternative approach is to measure potential pasture growth in exclosures which are burnt or mown at the start of the growing season. Such an approach may overestimate actual pasture growth compared to grazed pasture because of increased light interception and root development, reduced run-off and soil evaporation, lower frequency of unpalatable species, and biased sampling of landscapes.

## Season or Annual Calculation?

The sensitivity of pasture plants to grazing depends on the phenological stage of growth. Defoliation or burning has little deleterious effect in dry or dormant seasons and may even stimulate production by removing old stems. Thus, where growth is restricted by temperature or rainfall to distinct seasons (i.e. November to April in northern Australia) it is more sensible to calculate utilisation for this period rather than the whole year. However where growth can occur at any time of the year e.g. mulga grasslands, then an annual period is more appropriate.

A unifying concept of utilisation would be to calculate live (green) intake so that different durations of growing season could be taken into account. However such an approach requires estimates of diet selection between live (green) and dead, and length of period with live standing pasture, e.g. "green season".

# Average Utilisation or Utilisation in Dry Years?

Some evidence (McKeon et al., 1990) suggests that it is the grazing pressure or utilisation in the 30% of dry years that has the major effect on pasture deterioration and hence a "safe utilisation rate" should be calculated for a particular probability of pasture growth (e.g. decile 3) rather than for average or median growth (Scanlan et al., 1994). Thus estimates of the probability distribution of pasture growth are required. We use simulation models and historical climate data (e.g. GRASP, McKeon et al., 1990) to do this. For example, in Dalrymple shire, decile 3 production was 50-65% of average growth.

#### **CASE STUDIES**

In the following section we will examine some case studies from the black speargrass zone in Queensland to compare different approaches to estimating safe levels of utilisation.

# Utilisation in Defoliation Experiments and Grazing Trials

Howden (1988) compared the sensitivity to defoliation of three naturally occurring pasture species (*Themeda triandra*, *Heteropogon contortus* and *Bothriochloa pertusa*) in northern Queensland. Seedlings were grown in field pots and allowed to establish for 30 days. They were then cut 4 times (i.e. 2 weekly) during the wet season (90 days without moisture stress). Different "utilisation" treatments were achieved by cutting at different heights (2, 4, 8, 16cm and uncut).

There is an important distinction between expressions of utilisation as either potential or actual. The latter term includes any important feedbacks of utilisation on plant growth. For example for *Heteropogon contortus*, there was little difference between cutting treatments (range 42-47%) when expressed as potential utilisation ([removal/growth] in the uncut treatment). Severe defoliation reduced actual growth. Expressing each cutting treatment as actual utilisation rates (removal/actual growth) resulted in a wider range of actual utilisation levels (44-67%).

The ability of grasses to recover following grazing is closely related to the amount of foliage remaining and the capacity of the root system. In the grasses studied, the grazing-sensitive grass *Themeda* showed a marked reduction in the residual leaf area at actual utilisations above about 40% whilst this occurred at 45 to 50% respectively for the two successively more grazing-tolerant grasses *Heteropogon* and *Bothriochloa*. For all species, root mass declined significantly at actual utilisations above 40%.

The above-ground yields of *Themeda* and *Bothriochloa* were largely maintained under increasing utilisation rates mostly via decreasing partitioning of assimilate to roots and also, for *Bothriochloa*, through maintenance of residual leaf area. However, the reduction in underground biomass of *Themeda* may make it susceptible to competition from the other grasses restricting both nutrient and water availability.

A similar analysis (Scattini, 1973) was carried out for a constant stocking rate trial on black speargrass at Gayndah involving only summer-autumn grazing at average actual utilisation rates of 23, 41 and 77%. The major effects of the high utilisation rates (41&77%) were shown in the years following the droughts of 1963-4 and 1964-5. Grass basal area was substantially reduced in these periods and recovery was delayed in the following favourable years 1965-6 to 1967-8. As a result, loss of pasture production occurred (87 and 60% of production at lowest utilisation rate). The high utilisation rates also had less than half the burning opportunities, greater periods of low surface cover, and loss of black speargrass basal area.

# Utilisation at a Property Level

Many graziers have longer experience than can be obtained from grazing trials on research stations and are able to nominate a desired safe stocking rate for their property. In Dalrymple shire, northern Queensland, a survey of 45 properties was conducted to estimate pasture growth (Scanlan *et al.*, 1994). For all pasture communities on each property, estimates of grazing area, tree basal area, pasture condition, and rainfall were made. Rainfall use efficiency (kg/ha of pasture per mm of rainfall) were estimated for each community as a function of fertility, and humidity which is dependent on

distance from the coast and type of year. Pasture growth was calculated for each property and each year. Utilisation was calculated for summer period (182 days) based on an estimated potential intake of 10 kg of dry matter per day for an adult equivalent (AE).

For the 45 properties over the three years of the study (1987 to 1989), pasture utilisation ranged from 5% to 45% with the majority (85% of property/year combinations) having between 15 and 30% utilisation. Estimated safe stocking rates ranged from 3 to 23 AE/100 ha. Eighty percent of these estimated safe stocking rates were less than 35% utilisation of decile 3 pasture growth, i.e. the growth that occurs in at least 70% of years. Despite the wide range of rainfall, land resource units, pasture condition, and tree density, the majority (58%) of graziers' estimates translated into a relatively small range of utilisation (25-35% utilisation of decile 3 production). The change in actual stock numbers from 1987 to 1989 was compared to property utilisation rates. Properties with greater than 25% utilisation were reducing stock numbers, while those with less than 15% utilisation were increasing stock numbers. This study suggested that a consistent safe utilisation level of 10-20% of average production was seen as desirable and was the basis for buying or selling decisions.

#### Utilisation From Local Consensus Data

Grazier groups estimated safe stocking rates for 20 pasture communities in central Queensland (R. Clark *pers. comm.*). Stocking rates ranged from 14 to 62 AE/100 ha. Average pasture growth was calculated from regional rainfall and rainfall use efficiencies derived from a data bank of ungrazed pasture production trials (Gunsynd project). Potential utilisation for the summer growing season was calculated as in the previous case study. Potential utilisation rates ranged from 10-19% of average production with 70% of the communities in the small range of 14-19% utilisation. Whether or not such stocking rates are implemented is problematical (W. Burrows *pers. comm.*)

## Utilisation From Shire Statistics and Statewide Modelling

Tothill and Gillies (1992) evaluated each pasture community (e.g. southern black speargrass zone) and found variation in terms of deterioration and degradation. This variation in risk of degradation of different pasture communities requires both explanation and monitoring. Shire statistics of animal numbers reported each year (Australian Bureau of Statistics) can be used to calculate utilisation rates at a regional or pasture community scale.

A spatial computer model of pasture growth (Brook et al., 1992) has been developed based on the Gunsynd data bank. Pasture growth is calculated on a 5 km grid across the state (ca. 70000 pixels). Parameters such as transpiration efficiency are linked to pasture communities. Tree basal area has been separately calculated for each pixel from analysis of time series of normalised difference vegetation index (NDVI) using NOAA AVHRR satellite images (Danaher et al., 1992). Shire animal numbers have been distributed to pixels based on relative production within the shire. Deterioration or degradation are not presently included in the model, thus the calculated pasture growth does not include the major grazing effects on root yield, pasture density and composition. The model is currently being tested against ground truth observations of pasture yield and the time series of NDVI. For each pixel in each pasture community, a preliminary estimate of utilisation has been calculated. The spatial frequency distribution of utilisation provides an estimate of the risk of overgrazing in each shire and/or community.

## **DISCUSSION AND CONCLUSION**

We are using the concept of utilisation to link different scales of knowledge of the grazing system ranging from defoliation trials to regional stocking rate statistics. The analysis of defoliation and grazing trials shows the principles and quantitative relationships that allow sustainable utilisation rates to be determined. The analysis of property and LCD stocking rate data shows less variability in utilisation rates than in actual stocking rates, suggesting that, unlike stocking rates, safe utilisation rates can be extrapolated across a wide range of land resource units and climates. However, the apparent two fold variation in safe utilisation (10-20%) could: (1) indicate that there is a range of "safe" pasture use, dependent on managerial and resource differences; or (2) that a more accurate estimate of critical utilisation rate is required, including better estimates of pasture growth which account for spatial variability at a paddock scale.

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# THE ROLES OF BIOLOGICAL SOIL CRUSTS IN SOIL AND ECOLOGICAL PROCESSES IN RANGELANDS

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#### **ABSTRACT**

Biological soil crusts consist of mineral particles in association with various combinations of mosses, liverworts, algae, lichens, fungi, bacteria and cyanobacteria. Crusts are known to stabilise the soil surface against wind and water erosion, enhance the nutritional status of soils, and influence infiltration and survival of vascular plant seedlings by providing safe sites for seed lodgement. Their presence contributes to fine-scale patterning in the landscape, and they provide a useful indicator of soil surface condition. In this paper we discuss the distribution and function of biological soil crusts in Australia's rangelands, their roles in modifying soil and ecological processes, and the effects of fire and grazing on functioning processes.

## **INTRODUCTION**

Biological soil crusts, also known as cryptogamic, cryptobiotic, microphytic and microbiotic crusts (Eldridge and Greene 1994a) are unique associations of surface soils and microbiota including mosses, lichen, cyanobacteria, fungi, bacteria, liverworts and algae. They are found in most regions of the world which are sparsely vegetated or used primarily for grazing, and which are not intensively occupied or frequently cultivated, and which are not excessively stony, flooded or sandy (West 1990). Although their roles in infiltration processes are poorly understood, they are reputed to play a major role in landscape and soil stability, soil nutrition, biomass production, vascular plant survival, and are thus useful indicators of rangeland condition. They are however destroyed by heavy grazing and/ or fire (Eldridge and Greene 1994a).

## BIOLOGICAL CRUSTS AND INFILTRATION AND EROSION PROCESSES

There is conflicting evidence of how crusts influence infiltration. For example, studies in the semi-arid woodlands of eastern Australia have shown that crusts are most highly developed on soil surfaces in excellent physical condition, and are thus associated with high rates of infiltration (Greene and Tongway 1989). Other research has shown infiltration increases with increasing crust cover, but only on degraded surfaces (Eldridge 1993a,b). Scalping experiments have demonstrated enhanced infiltration after crust removal (Graetz and Tongway 1986, Greene and Tongway 1987). Whilst difficult to reconcile, differences in response to infiltration may be related to different soil physical properties between the various studies.

It is widely accepted that biological crusts generally reduce erosion (West 1990, Eldridge and Greene 1994a), though there are few data for wind erosion. Eldridge and Greene (1994b) showed that crust levels of 50% or more restricted splash erosion to low levels, and resulted in a low loss of fine particles.

# BIOLOGICAL CRUSTS AND SOIL PHYSICAL PROPERTIES

Biological crusts enhance the stability of soil aggregates (Eldridge and Greene 1994a). Fungal hyphae present in lichens bind microaggregates (<0.25 mm) into macroaggregates, which are generally more stable to raindrop impact. Crusts also secrete amorphous gel-like materials and polysaccharides which bind algal cells and filaments and mineral particles into stable units. This effect is greatest within the top few mm. Larger biota such as mosses and lichens reduce erosion by providing a physical barrier to raindrops at the surface.

#### BIOLOGICAL CRUSTS AND SOIL ECOLOGICAL PROCESSES

Biological crusts can fix up to 41 kg N/ha/yr (West 1990), and pot studies have demonstrated the transfer of nitrogen and essential nutrients to higher plants (see Eldridge and Greene 1994a). Small falls of rain activate this nitrogen fixing process. Given threshold levels of rainfall for germination of vascular plants, a source of available nitrogen is readily available to produce a growth response. Recent research has also shown that crusts sequester organic carbon directly into the soil via photosynthesis (Beymer and Klopatek 1992).

Biological crusts have been shown to increase the survival of vascular plant seedlings, possibly through enhanced microrelief and soil nutrient status. Australian research, however, is far from conclusive (Eldridge *et al.* 1992), and results could be related to seed size and shape. Crusts may also provide niches for soil invertebrates (Greene *et al.* 1990), but few studies have been undertaken.

#### MANAGEMENT FACTORS AFFECTING BIOLOGICAL SOIL CRUSTS

Studies of fence line contrasts and water points reveal that crusts are susceptible to disturbance by trampling and grazing. Recovery from disturbance is generally thought to be slow, possibly as a result of loss of fine material during erosion.

Fire also reduces the coverage of soil crusts (Greene *et al.* 1990), destroying the gels and mucilaginous sheaths holding together the soil material. Continuous burning is associated with decreased resistance of the surface to wind and water erosion (Greene *et al.* 1990). Crust recovery after fire is slow, and values up to 13 years have been reported for some sandy soils (Eldridge and Bradstock 1994).

#### MANAGEMENT OF BIOLOGICAL CRUSTS FOR SUSTAINABLE LAND USE

Because of the extensive nature and relatively low economic value of rangelands, management options are restricted to broad-scale, low-cost strategies using manipulation of grazing and fire. Conservative stocking is recommended as a generalised strategy to protect the soil and vegetation against degradation, particularly during drought periods. During droughts, biological soil crusts may be the only form of soil protection on many surfaces. Thus it is important to reduce grazing intensity by increasing the number of watering points, or dispersing stock over larger paddocks, to reduce the risk of damage to the crusts (Eldridge *et al.* in press). Wise management practices will ensure the maintenance of organic carbon in the soil, improve nitrogen fixation, and probably enhance the survival of vascular plant seedlings. Long-term overgrazing of soils in good condition may lead ultimately to a loss in productivity, destruction of soil structure and a reduction in spatial heterogeneity at the soil surface. Some practices such as blitz grazing may not be consistent with the development of a stable biological crust cover, which is essential to reduce the risk of wind erosion (Greene *et al.* in press). Whilst fire is a useful management tool, its overall effect may be disastrous because it removes the biological crust. Frequent fires may remove crusts, reducing infiltration and erosion.

## **CONCLUSIONS**

Biological crusts have been shown to be important components of healthy landscapes, affecting various soil and ecological processes. Research has shown that crusts are strongly affected by management systems which involve frequent use of fire and high levels of grazing. Inappropriate management leads to a decrease in the biological components of soil crusts and increases in runoff and erosion.

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#### WHERE IS RESEARCH BEING DIRECTED?

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#### **ABSTRACT**

Past rangeland research focussed strongly on support for the grazing industries. Declining fortunes for those industries and changing patterns of land use have forced a re-examination of the priorities for research. Government agencies and R&D Corporations are now struggling to set new research directions in the rangelands in a time of rapidly changing social, economic and cultural imperatives. Fundamental questions deal with what the community wants from the rangelands and its uses, and how the values that influence those expectations can be accounted for in setting research directions. We argue for exposing these social values and integrating them with scientific judgments in a decision analysis approach to setting research directions.

## **INTRODUCTION**

Historically, research directions in the rangelands were set mainly by researchers trained in the agricultural reductionist tradition, with the context being a need to understand the workings of the bio-physical systems and a widespread concern about over use and land degradation. Researchers were responsible for designing and implementing research work mainly oriented towards the use of the land for grazing within individual land holdings (Russell and Ison 1992). Further, the primary focus was on developing bio-physical knowledge that could enhance sustained production from the land. The body of work done within this tradition has given Australian rangeland scientists and managers of grazing enterprises a wide and beneficial knowledge of the nature and functioning of the biology of the rangelands (e.g. Harrington *et al.* 1984).

### THE CHANGING GROUND RULES IN THE RANGELANDS

The grounding of research directions in an assumed continued dominance by a single land use - that of grazing use, is now seriously challenged. The declining economic status and performance of the pastoral industry and the emergence of competing land uses have eroded the basis for that dominance (Holmes 1994a, Robertson 1994). Recent reviews have highlighted the low rate of adoption of research-based recommendations in the grazing industry (Morton and Price 1994, Wilson 1994). As a consequence, the value of undertaking further traditionally constructed productionbased research in some range ecosystems is being seriously questioned (Morton and Price 1994). Further, the emergence of new policy directions that will influence the rangelands and its users (Holmes 1994a) suggests a change in the fundamental values attached to rangeland use by the Australian community. How do we know what these new values are, how widely shared are they and how committed is the community to these new policy directions? A suggested lack of agreement within the community on what it expects from the rangelands is seen as a constraint to progress in rangeland management (Morton and Price 1994). In our estimation, the problem arises in part because the community's collective 'mind-set' about rangeland use is poorly articulated and therefore not well understood by people working in rangeland environments. The Australian Rangeland Society is attempting to address this problem by surveying urban communities to determine the range of beliefs, attitudes and values held about rangeland use.

The shift from a context of grazing use no longer being the sole use for rangeland but one of many complementary and at times competing land uses, combined with an absence of clearly identified community requirements in the rangelands has injected a major new uncertainty into the decision making environment. This uncertainty has extended to setting policy directions for research in the rangelands (Morton and Price 1994). Decisions about rangeland research are no longer the private preserve of plant and animal ecologists interested in achieving sustainable domestic animal production. Other people in the community and researchers in other disciplines are identifying different research needs and methodologies (Morton and Price 1994, Holmes 1994b, Ison 1992). Attempting to set long-term research directions in a time of major social, economic and cultural changes in the rangelands adds yet another layer of complexity into the process (Morton and Price 1994) which is likely to weaken the quality of any policy formation process (Hammond 1978).

## Values Affecting Practice - Rangeland Surveys in Western Australia

Systematic survey-based descriptions of the bio-physical rangeland resource began in W.A. in the 1960s. The reports produced to date describe the land and its condition mainly from the perspective of its use for grazing (e.g. Payne *et al.* 1987, Payne *et al.* 1988, Wilcox and McKinnon 1972). Other groups and agencies in the rangelands have perceived the work to be grounded exclusively in the grazing use of the rangelands and this has limited the value they have attached to the findings from this rigorous and expensive research program.

Given the changing context for rangeland management described in earlier sections, we have recognised that the perceived grazing use focus of the data collection and reporting has been limiting the potential client base for the findings. Additionally it was realised that this focus may reduce the temporal relevance of our work as alternative and multiple land uses emerge. Meeting the requirements for ecologically sustainable land management at a regional scale (as defined by Morton and Stafford Smith 1994) implies that we must undertake 'resource' rather than 'pastoral' investigations. One response to these external imperatives has been to recognise our own subjectivity in data interpretation and to discipline ourselves to make observations rather than value-laden interpretations (Pringle *et al.* in prep.).

Changing the focus of the survey work to reflect changing values, circumstances and imperatives has not occurred without some pain and the change process is far from over. Nor will it ever be complete if we accept that the focus of the work will always be responding to changed needs. In the meantime, the outcomes from changes to date are that we have enhanced the participation of the traditional clients (land holders) in the survey process; and we are working with an increasing list of new clients such as mining companies, conservation groups, environmental consultants, research organisations and Government agencies. Finally, we are better able to make credible contributions to rangeland strategy and policy development.

## THE ROLE OF VALUES IN SETTING RESEARCH DIRECTIONS

We are not able to address all the issues related to setting research directions in the Australian rangelands. In this paper, we confine our attention to the proposition that a critical role for human values in the formation of rangeland R&D directions has been generally ignored and perhaps even denied by those responsible for setting those directions.

Our questions are 'How can researchers be sure that their research directions closely reflect the range or aggregate of community values or expectations for the rangelands?' and 'How can human values be considered alongside scientific judgments in the development of policy?' Government agencies and Research and Development Corporations are struggling to interpret community and rangeland users' needs into policy for research and development directions (Morton and Price 1994). At a practical level, much of this conceptual work continues to be done by the rangeland scientific community although increasingly rangeland managers (e.g. land holders, conservation reserve managers) are becoming involved in the process.

While viewing their thinking as objectively 'rational', the context in which that thinking occurs is inevitably subjective, given that it is grounded in a suite of values that is rarely exposed and shared with others. Thus agency decision makers can make serious errors in their assumptions about public expectations of their management decisions. Bureaucrats may assume that all people share their value systems - for instance that everyone believes in the scientific-rational paradigm of resource management. People can interpret the same information quite differently, according to the values they use to interpret their world. At the extreme a utilitarian view can regard conservative grazing as wise use, whereas a person holding spiritual values about the land can regard grazing as a profane act (Brunson 1992).

Although agency management decisions may be prescribed by legislation, the values held by agency staff can change subtly over time. Changing values can influence particular resource management decisions which can have a profound effect on resource-dependent communities (Cramer et al. 1993). Arguments over public policy usually occur as a result of disagreements about values (Gardiner and Edwards 1975). Yet when values become overtly important in decisions, bureaucratic decision makers may respond by depreciating such decisions as 'value judgments', without recognising that making judgments is a primary reason for their existence (Coates 1978). Further, scientific

information and progress is increasingly judged in the context of human values. Ultimately, the formation of public policy requires an integration of the products of scientific endeavour with human values. A key element in this process is human judgment, a cognitive activity generally but erroneously thought to be incapable of analysis (Hammond and Adelman 1976).

Quality decision making requires that the social value context in which the decision is made is well understood. The literature reviewed above suggests that this is not usually the case. This can lead to scientists assuming the function of determining and articulating social values - a role for which they are not equipped and where they have no authority. Not surprisingly, they may mis-judge the communities' requirements (e.g. Brunson 1992). On the other hand, community people who should be responsible for establishing social policy may find themselves disputing scientific information with the originators of the data - the scientists. Now it is the community's turn to operate beyond its level of competence! Thus we can have community members vainly attempting to interpret scientific facts as informed by their social values; with scientists struggling to interpret and develop social values guided by their judgments of the facts. The suggestion is that this occurs when the wider community and scientists accept an adversarial approach to setting objectives and making decisions (Hammond and Adelman 1976). The difficulties described in setting directions for R&D in the Australian rangelands suggest that a situation like this may be contributing to a state of confusion between scientific and valuative judgments in determining policy or research directions.

# RESOLVING THE PROBLEM

Systems (or systemic) thinking, soft systems methodologies, participative inquiry and the use of action research methodologies can establish the context for a process of community involvement in setting objectives for the rangelands (e.g. Bawden and Packham 1991, Ison 1992, Russell and Ison 1992). The findings from the use of specific pragmatic models of intervention can be examined within this wider context (Russell and Ison 1992). The four requirements for providing effective decision making in resource management in a multi-value world are: the search for common ground; management at larger spatial and temporal scales; an integrated approach to management, research and extension; and a better attention to the role of the community's social values in determining desired uses and management (Brunson 1992).

We focus our attention on the first and last of these requirements. To handle the confusion of facts, judgments and values described above requires specific models that allow for the separate investigation of scientific and social values judgments, followed by their rational, analytical and visible integration into research directions. Firstly, these mechanisms should enable the values that influence decisions about rangeland use to be studied and debated in relative isolation from scientific judgments which may or may not be grounded in an entirely different set of values. Conversely, the thinking that underlies scientific judgments about the desirability of future directions needs to be examined for its valuative basis. Finally, we need a procedure within this new model that overtly and objectively integrates these scientific judgments and community values into research directions that are more broadly acceptable and in keeping with the whole Australian community's objectives for our rangelands.

A decision-analytic approach has long been recommended to address conflicts and confusion in land use regulation. This methodology resolves conflicts at the level of decision rules rather than arguing afresh over each new case. Multi-attribute measurement allows the weighting of each decision attribute to be established in isolation before moving to a choice. Importantly the decision rules are public and can be changed as circumstances (and values) change (Gardiner and Edwards 1975). Decomposing a complex decision such as setting research directions into its component parts allows the debate to occur at the level of these components where areas of agreement and disagreement can be made clear. In a public research directions setting process, the focus can be on consolidating the areas of agreement and working hard to accommodate the areas of disagreement. Finally, a decision-analytic approach to setting research priorities can define what is feasible and achievable in a management environment (Norton and Walker 1985).

Providing people with a formal model to aid decision making facilitates the proper consideration of values in decision making. People have great difficulty in describing their values in isolation from an issue or event. The role of values is best approached in terms of the behaviour of the value holders. Providing specific analyses, options and propositions in the form of a decision model allows people

to use their values (and hence reveal them) in weighting criteria and making choices (Coates 1978). The multi-attribute and hierarchical decision models proposed in the literature to assess land use and management options for their relative achievement of sustainability (e.g. Lefroy et al. 1992; Morton et al. in press) offer a framework for addressing these requirements. The National Rangeland Management Strategy being developed will seek to identify the criteria for assessing future land uses and define a process for decision making (Robertson 1994) - in short, to make these models work. Both of these models recognise that a use must meet a desired level for social criteria or feasibility if it is to be sustainable. Both groups of authors allude to difficulties at this level in the operation of their model. Importantly, these models would permit the decomposition of the process of assessing sustainability into its component parts followed by an integration into a final decision. Thus they can be employed to separate the use of bio-physical or economic information to make scientific judgments from the social value judgments made in the community. A process of integrating these sets of judgments using some agreed criteria could then follow.

These models can be used to structure the debate conceptually. A recent research directions workshop in Western Australia used a modified version of a land use decision making model within a soft systems process to determine the research needs required to make the model work (Z.G. Yan pers. comm.). In defining the transformations occurring in the system's bio-physical, economic and social sub-systems, the participants were able to determine deficiencies inhibiting good decision making. The values held by the participants were exposed and discussed in the process. A more formal use of the model involves separating the social values and scientific judgments and then externalising the weightings that people place on different criteria involved in making judgments in these two areas. Finally the two types of judgments are integrated according to an agreed relative importance for the two areas (Hammond and Adelman 1976). This methodology, which can cause participants to choose options that were initially overlooked, has been used in setting public policy in a range of environments, but it may be overly complex to use in all but very difficult situations.

## CONCLUSION

A decision-analytic approach to handling the influence of social values on research directions using the available decision making models is recommended. This approach has been useful in other decision making environments and it warrants further testing in the rangelands. At a conceptual level, we believe the approaches described provide a framework to guide thinking and dialogue in setting research directions. At a more formalised level, the decision making models already in place can be used to integrate scientific and social value judgments into decisions that properly reflect the community's aspirations for the rangelands.

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# LAND CAPABILITY AND LAND IMPROVEMENT

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# PASTORAL WATER HARVESTING / STORAGE SYSTEMS

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#### **ABSTRACT**

Design and costings for successful water harvesting and storage structures in pastoral areas are described. The designs effectively service waterpoint stock numbers, minimise evaporation from storages, reduce siltation and have low capital and maintenance costs. The poster display demonstrates that, with appropriate planning, design and construction, accounting for specific soil properties, effective surface water harvesting and storage structures may be economically developed. These structures have special applications in pastoral areas where increased numbers of waterpoints and better distribution improves rangeland management and productivity when combined with appropriate animal control.

# INTRODUCTION

Historically, large dams have been employed by the pastoral industry in areas devoid of suitable groundwater supplies. Technical investigations in Western Australia's rangelands have demonstrated that small efficient catchments on properly designed and constructed dams produce cost effective stockwater facilities.

#### DESCRIPTION

Required storage volume is calculated using potential carrying capacity (5km grazing radius), stock drinking rates, evaporation data and time period to storage recharge.

Catchments are selected on the basis of indications of high rainfall run-off production and adequate size to fully service projected storage requirements, even in dry years. Natural catchments that do not meet these criteria may be modified to increase run-off efficiency and catchment size using catchment drains. These drains concentrate overland flow and convey it to a temporary storage area outside the dam. Drains are constructed on a grade of 0.25 per cent, or less (depending on soil type). Catchment drains are designed to safely handle maximum expected flows.

Damsides are test drilled prior to excavation to confirm depth and quality (water holding capacity) of material down the proposed excavation profile. Material recovered from test drill holes is tested on-site for clay content, strength and dispersion. Drilled test holes are checked after 24 hours for any evidence of a saltwater table.

Round dams are preferred to either square or oblong. For an excavation of a given depth, base width and batter slope, round dams provide equivalent storage with less excavated volume.

Formulae used in dam design are:

# Round dam

Volume (m<sup>3</sup>) =  $0.2619 \text{ X Depth X } [\text{Td}^2 + \text{Bd}^2 + (\text{Td X Bd})]$ 

Where: Td = Top diameter (m)

Bd = Base Diameter (m)

# Square or Oblong Dams

Volume = A + B +sqrt $A \times B \times (Depth/3)$ 

Where: A = Top surface area (m<sup>2</sup>)

B = Base area (m<sup>2</sup>)

Batter slopes of 3:1 (or steeper) are constructed as steep batters reduce surface area (and therefore evaporation) for a given stored volume. 'Bogging' is also minimised as stock do not wade into the dam; stock walk up steep batters by moving diagonally across the contour. The batters are constructed contiguous with the dam wall, which has 1.5m of free board. The dam wall provides some protection from cross winds which accelerate evaporation. This style of construction also minimises the batter catchment area, which reduces batter erosion.

The base of the dam is relatively small (24.5 metres diameter), which promotes greater depth of stored water for any given inflow. Storage depth of at least 6 metres is required to counter high evaporation rates. Dam evaporation rates are approximately 70 per cent of Class A pan rates. The greater the depth the cooler the water; cool water evaporates at a slower rate than warm water.

Dam siltation is greatly reduced by utilising piped fluming. Pipes convey water from the temporary storage area to the base of the dam, greatly reducing batter erosion. With the correct combination of pipe size and number used, together with a temporary storage area, the need for a silt pit is eliminated. The inlet to the pipes is protected against siltation and debris-caused pipe blockages:

Temporary storage is created through impounding by wingbanks. The wings also facilitate the above-ground storage of up to 0.5 metres additional depth of water. Design volumes for temporary storage areas may be 30 per cent of dam volume in reliable summer rainfall areas but rises to 100 per cent in unreliable winter rainfall areas. Overflows are created at the extremities of the wingbank(s). These overflows are flat and wide to reduce soil erosion potential. Some unstable overflows require protection from grazing animals. All earth used in wingbank and overflow construction is taken from the rear of the wingbank and not from the temporary storage area. Wingbanks are constructed to create 1.5 metres of freeboard.

#### COSTS

Costs associated with construction of a dam/catchment stockwater point are:

- Site selection, design and surveying (if applicable)
- Earthmoving machinery mobilisation
- Construction of access to dam site
- Dam excavation, usually costed in dollars per cubic metre excavated
- Wingbank and catchment drain construction; costs on an hourly basis
- Piped fluming purchase
- Cement purchase for inlet abutment and apron. A concrete spreader pad may also be required at the pipe outfall
- Labour for piped fluming installation

The approximate capital cost of constructing a facility as illustrated on the poster is \$70/cattle unit.

Ongoing maintenance costs are minimal. The facility is largely maintenance free if properly designed and constructed.

# LAND RESOURCE SURVEY: AN INFORMATION RESOURCE FOR RANGELAND MANAGERS

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# **ABSTRACT**

Information produced from land resource surveys can provide land managers with a useful tool. It forms a necessary basis for sound land management decisions. The challenge is to produce the information in a format which managers can readily incorporate into their planning of station developments and management. GIS can increase our capability to produce relevant products quickly. This poster outlines a project on an Alice Springs cattle station. Working closely with the station manager a series of specific maps, on a paddock basis, have been produced from land unit information. These maps are proving useful for various aspects of land management planning including grazing management, weed control, fence and track alignment.

#### INTRODUCTION

Land resource information for rangeland management and conservation is collected by the Conservation Commission of the Northern Territory's Land Conservation Unit (North and South). This takes the form of land unit mapping with accompanying information and management guidelines. Primary users are managers of pastoral lands and support agencies. This poster describes work done by the Land Resource Assessment section (South), which covers the Alice Springs and Barkly regions of the Northern Territory.

# CONDUCTING SURVEYS

Land resource information is collected by a combination of stereoscopic interpretation of aerial photos and field survey. Generally colour aerial photos at a scale of 1:50,000 are used, with satellite imagery and other information sources such as geological mapping also being considered. A field survey is conducted comprising about 100 detailed recording sites per station (1 site per 30-40km²) with mapping observations along traverses between the sites. This is used to ground truth the aerial photo interpretation. At each site detailed information on landform, soils and vegetation is collected along with general observations.

### THE PRODUCTS

A map of pastorally different land units with a self-contained legend is produced. The legend contains a brief description of landform, soils and vegetation for each unit using simple terms and common names. Land management information such as erosion hazard and pastoral potential of each unit may also be included on the legend. Reports describing each of the land units along with land capability assessment and management guidelines accompany the maps. In addition, thematic maps coloured specifically for Erosion Hazard and Pastoral Potential may be produced.

Previously the primary products have comprised these three types of map - with laborious hand-colouring of maps limiting the speed with which we could present alternatives. By entering the era of computer technology and utilising the CCNT's ARC/INFO Geographic Information System (GIS) this limitation has been lifted. There is now increased scope to produce specialised professional quality products tailor-made to suit the individual landholder. This enhances our capacity to provide interpreted resource information for decision-making.

This poster details work which has been done on Narwietooma Station, 130km north-west of Alice Springs. Whole property maps have been produced at 1:100,000 and 1:50,000 scales. In addition individual paddock maps have been produced for specific themes including:-

- \* areas where spelling would be most effective,
- areas to be avoided when constructing roads and fences,

- \* areas of spinifex where burning would promote the best pasture improvement,
- \* areas where woody weeds may become a problem and
- \* areas where mimosa bush (Acacia farnesiana) may become a threat.

# **APPLICATIONS**

The maps and reports complement and extend the knowledge that managers already have about their station. They enable managers to quantify the land resources available to them and clearly define the capability of these resources. The use of GIS can enhance this capacity. Presenting the information accurately on paper can be invaluable for planning of future developments and management. Breaking the information down to the paddock level allows land managers to consider issues at their usual planning scale. This avoids the problem of people being overwhelmed by too much information.

#### REHABILITATING ARID RANGELANDS - DO PITTING AND OPPOSED DISCING WORK?

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#### **ABSTRACT**

We reviewed the effectiveness of popular techniques of mechanical rehabilitation in the Alice Springs district over the last twenty years. In the majority of areas that we assessed, the response was poor. Could we develop simple "ecological" indicators for predicting where rehabilitation was most likely to succeed? We tested many potential indicators - attributes of soil quality, landscape and rainfall - at sites throughout the region.

Buffel grass (*Cenchrus ciliaris*) was the only species that became widely established. Success was most likely when soils were relatively sandy, the surface crust was fairly weak but stable when wet, microtopography was well developed and the average rainfall was 250 mm or more. In general, pitting and opposed discing were useful for pasture improvement in well resourced sites but not for rehabilitating eroded or poor quality sites.

#### **BACKGROUND**

Pitting and opposed discing have been popular rehabilitation techniques in central Australia since the early 1970s, when they were effective in dust control works. Pitting machinery produces three rows of offset pits on each pass and two passes are usually made side-by-side. The opposed disc plough creates a single discontinuous row of paired furrows either side of a longitudinal mound. Commonly, two offset rows of "staggered furrows" are generated by two passes of the opposed disc plough, and these are alternated with two passes of the pitter. Almost without exception, exotic species, especially varieties of buffel grass, have been sown during treatment.

Our first aim was to survey representative treated areas across the Alice Springs district. It was soon apparent that pitting and opposed discing did not always work. Consequently, our second aim was to develop simple "ecological" indicators for predicting where rehabilitation had the best chance of success.

We tested many potential indicators (see e.g. Tongway 1994):

- \* soil quality e.g. texture, colour, pH, stability, evidence of erosion
- \* rainfall e.g. average annual, average summer, amount following treatment
- \* landscape features e.g. upper/mid/lower slope, runon/runoff

and measured indices of vegetation biomass by species. We made 44 assessments across the region, over a wide range of average annual rainfalls from 200 mm in the south to 330 mm in the north, and on what were or had been loamy soils at least 10 cm deep on slopes of 2% or less.

# **RESULTS AND DISCUSSION**

Maximum forage improvement on the very best site was an extra 350 kg/ha, in a slightly below average year. For about 80% of the sites the improvement was only half that amount or less, and for 60% of the sites it was a quarter or less. Economic analysis (Friedel et al. 1994) showed that, typically, with average stock, economic losses were almost guaranteed. This was because, in general, treatments had been applied to the very worst-looking areas, where water and nutrient relations would be poorest.

# **Ecological Indicators**

Since buffel grass was the only species that was widely successful, the results largely apply to buffel, although some native species responded too. Listing influential indicators in order of importance, the best response to mechanical treatment was obtained where:

\* Surface soils were sandy clay loam or sandier or, in some cases, sandy lag was still present after some erosion. Clay content above 25% gave poor results (Fig 1a).

<u>Reason</u> Water infiltration is easier in sandy soils. The roots of newly germinated seedlings can penetrate more readily too.

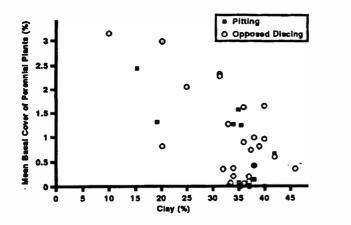
- \* Soil crust was relatively weak and could be broken with gentle thumb pressure.

  <u>Reason</u> A strong crust can indicate clay, or a stripped and nutrient-poor subsoil, or a "cryptogamic" crust of tiny lichens, algae and fungi which repel water. All can disadvantage water infiltration and germination.
- \* Average annual rainfall was more than 250 mm or else the area was nutrient-rich and received extra runon (Fig 1b).

  Reason Perennials need reliable soil moisture every year to persist, though they may establish in a wet year in drier country.
- \* Soil surface had well developed "microtopography" i.e. was uneven on a scale of centimetres.

  Reason Small hollows trap resources e.g. water, organic material and seeds, which otherwise would wash or blow away.
- \* Surface soil was stable and did not collapse quickly on wetting.

  Reason Unstable soils make a slurry when wet and block up the soil pores created by ants, termites and old root channels. Water cannot penetrate easily and will evaporate or run off. Seedling establishment is difficult when the surface is mobile. Structures created by mechanical treatment may slump quickly, too.



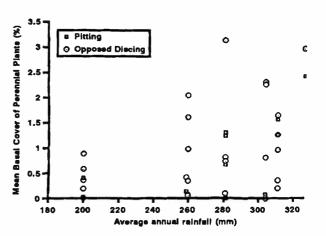


Figure 1. Mean basal cover of perennial plants plotted against (a) soil texture class (expressed as % clay) of the untreated soil and (b) average annual rainfall.

# **CONCLUSIONS**

Simple ecological indicators have been devised to test the suitability of sites for pitting or opposed discing. In general the value of these treatments lies in pasture improvement for high potential areas, although introducing exotic species to native pastures may create a conservation dilemma. Poorer quality sites may require water ponding techniques.

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# THE ROLE OF ROADS AND TRACKS IN INITIATING GULLY EROSION ON CENTRAL AUSTRALIAN RANGELANDS

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#### **ABSTRACT**

Inappropriate road and track alignment has long been recognised as a cause of gully erosion on semiarid rangelands. However, many land users have yet to develop or adopt improved practices for planning and construction, so this simple problem remains a major land management issue.

Often the role of roads and tracks in initiating gully erosion is hard to identify. This poster presents a case study of a central Australian catchment where there is a close correlation between existing gully systems and prior access tracks. The connection is not readily apparent unless viewed in the context of track alignments established up to ninety years ago which are no longer visible on the ground.

#### INTRODUCTION

The key message of this poster is a simple one - the inappropriate siting and construction of roads and tracks is costing central Australian rangelands dearly. The same problems exist with other types of graded lines including fencelines, firebreaks and seismic lines. These earthworks are possibly the major cause of gully erosion within the region.

Erosion along roads is commonly perceived as a routine maintenance problem, mainly impacting on ease of access and vehicle wear. The environmental costs include the destruction of pastorally productive and ecologically-rich drainage line areas, the diversion of run-on from floodouts and the redistribution of sediment. While these effects lack immediate economic or social consequences, they result in a long-term decline in the productivity of the land resource. Unfortunately, the repair of gully erosion on rangelands is difficult in both technical and economic terms (Duggan *et al.*, 1981).

The recognition of roads as a major cause of erosion on rangelands is not new. Condon *et al.* (1969) considered vehicle tracks and flat graded roads a serious problem after assessing central Australian pastoral properties during the 1960s drought. Using historic information, Cooke and Reeves (1976) found that large arroyos (gully systems) in Arizona were commonly initiated by the disturbance of drainage floor surfaces by wagon tracks or ditches. However the role of roads or similar linear surface disturbances in initiating drainage incision is often forgotten when gully systems are inherited by successive generations of land managers.

# A CASE STUDY

Gully systems in the upper reaches of the Todd River catchment north of Alice Springs contribute substantially to the fine sediment load carried by intermittent flow events (Duggan *et al.*, 1981). An alignment of linear gullies observed during a resource assessment of the catchment in 1993 suggested that they were related to old tracks. Subsequent mapping of prior access routes from 1950 aerial photographs confirmed that most gully systems within the study area were associated with old roads and tracks located on alluvial landforms. The tracks can be differentiated from stock pads since they directly connect landmarks and access points.

No local 'old timers' have been found who can provide an early history of the catchment. However one series of gullies aligns with an old road to the Winnecke Goldfields mapped on a 1940 pastoral map and apparently in existence as early as 1903 (Coulthard, 1903). The main point of access to the Station Creek subcatchment was adjacent to a rocky gap where the drainage converged. Consequently station access tracks radiated along drainage lines and now persist as gullies and creeklines. Stream gauging equipment was installed on one track (creek) during hydrology studies in the 1960s.

#### BEST PRACTICE FOR SUSTAINABLE RANGELAND MANAGEMENT

New roads and tracks continue to be constructed throughout the rangelands. How many of these will eventually exist as gullies or watercourses when no longer obvious as thoroughfares? Hopefully very few as awareness of this issue is increasing.

Most of the environmental damage caused by roads and tracks is avoidable if basic planning and construction standards are adopted. Land management agencies are now placing a greater priority on generating awareness of these best practices as knowledge of their importance develops. The pastoral industry is receptive to improved practices as demonstrated by a focus on road construction at a recent Centralian Land Management Association field day at Napperby Station. This landcare group proposes to undertake a program of on-property demonstrations of best practice in conjunction with the CCNT Land Conservation Unit and Bushfires Council.

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# MANIPULATING WATER: IS NOW THE RIGHT TIME FOR EXPANDED USE OF THESE TECHNIQUES IN CENTRAL AUSTRALIA?

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#### **ABSTRACT**

Although the technology to adequately use waterponding and waterspreading has been available for many years, it is argued that social and economic, rather than major technical problems, have restricted development and systematic use of these in central Australia. However, changes in a number of these factors, well documented local "on farm" successes with the techniques and the discrediting of pitting and discing as long term ameliorative measures combined with producer-driven renewed interest could see expanded use of the technologies in the future.

# INTRODUCTION

There are a number of different components in manipulating water. Those of principal interest are water spreading, which is the collection or harnessing of runoff for controlled release onto areas for biomass production; it may also have a component for erosion control.

The other technique is that of waterponding, which involves the ponding of shallow sheets of water, primarily on scalded or denuded land [but not necessarily always] to achieve a change in soil properties which will allow the establishment and persistence of a productive pasture cover. Techniques for this treatment can vary, and names used include waterponding, ponding banks, diversion spreader banks, grader banks or similar titles. Often the height and cross section of the banks vary considerably, this being generally related to the slope and character of the land.

# THE CURRENT SITUATION

During the 1970s and 1980s, the predominant interventionist techniques for rangeland in the region lother than fencing, yards and water], were pitting or opposed discing. Although widely used, recent information has indicated that the techniques were generally unsatisfactory in providing any long term relief or modification to the rangeland environment and enhancing range plant productivity (Friedel *et al.* 1994, Friedel *et al.* this volume). For about 80% of sites surveyed, in a year of only slightly below average rainfall, the improvement in forage production was 180 kg/ha or less; with the very best site only achieving an extra 360 kg/ha of forage. For most situations, it was not economic, although at some good sites, returns of the order of 10-20% were obtained.

With hindsight, use of the technique has not been broadly successful or as importantly, durable, for many areas treated have reverted to "flat" areas due to the filling in of pits over a relatively short period. This means that repeated treatment is required for lasting benefit.

#### WATER PONDING AND WATER SPREADING

These two technologies which enhance water infiltration seem to offer better options than pitting or opposed discing in improving productivity from rangelands. Yet the utilisation of the technologies has been poor in central Australia, a physical location with generally good potential with moderate frequencies of rainstorm-generated runoff from suitable catchments and runon areas for utilisation of the water. Could the social and economic issues of the preceding 25 years be of greater importance than the physical and practical realities in determining use of these technologies? Some of these factors are outlined in Table 1.

Over this period the level of understanding of the rangelands has increased. Community attitudes toward successful land management now tend towards a benign effect on the rangeland resource. However, it is still not clear as to the correct methods of achieving this. Does the present time now provide a context in which water manipulation could be seen as a tool for better land management, which may lead to both improved land resources management and improved productivity and profitability?

Table 1. Social and Economic Events Significant to Pastoralism in Central Australia

Period	Social and Economic Events and Attitudes
pre-1966	The early 1960s saw all of central Australia in a major drought with low economic activity in the cattle industry and considerable stock losses and possible damage to rangeland
1966-1974	drought recovery with a succession of wet years and high pasture productivity, especially in the early 1970s when rainfall was the highest on record, with a succession of excellent years for rangeland productivity and opportunities to rebuild economic net worth and some early interest in water management until
1974-1978	disastrous collapse of beef prices combined with a return to more normal rainfall and weather patterns
1978/80-1990	concentration of property management and resources on the BTEC campaign, at times with mandatory requirements for particular station management practices, moderate to low cattle prices and continual cost/price squeezes, excessively high interest rates [late 1980s] and latterly the more general economic malaise
1990s	re-orientation of property management after BTEC, changes in community attitudes towards need for sustainable land management, Decade of Landcare and changes introduced through that campaign, introduction of the National Property Management Planning campaign, a complete re think of agriculture away from production orientation [almost at all costs] to a sustainability of production, with fewer resources or inputs, improved attitudes and understanding of rangelands and their resources, generational change in age of pastoral managers, demands for increased incomes to support a higher standard of living, better market prospects for beef due to rejuvenation of the economy (from 1993) and improving export prospects.

In the past, erosion control measures have been mainly initiated by government agencies, rather than by pastoralists to enhance productivity and economic success. In some cases these have been very successful (e.g. the Alice Springs Dust Control Project). However, some pastoralists have been dissatisfied with the long term success of the measures used, both for productivity and land resource protection and in recent times have become aware of the very successful work done in NSW with other methods. Results of local "on farm" testing of ponding banks are also available (Purvis, 1986; Bastin, 1991) while recent work was demonstrated on another Centralian property at a field day in 1992. These results, which showed at least ten fold gains in pasture production from using ponding banks, reinforce the potential for enhanced forage productivity from rangeland using the water ponding type technology.

# THE FUTURE

There appears to be renewed interest in the use of water ponding techniques. Recent interviews with Centralian pastoralists confirm this trend. That the Centralian Land Management Association has organised field days examining ponding banks also augers well for the success of the technology in future years. Economic analyses (Cann unpubl. data) show that the highest returns appear to be obtained through utilising treated areas for increasing the unit value of stock prior to sale. The paucity of data over broad areas on forage production, utilisation levels and animal performance preclude adequate in-depth analysis. However the economics do look promising.

# **CONCLUSIONS**

Current work aims at collecting and reviewing past research and knowledge on the topic including experiential knowledge from users to provide a basis for assisting decision making by both users and policy makers.

Aspects of interest where data are scarce include:

- how to use the techniques for greatest cost effectiveness within the enterprise
- forage and animal production from treated areas, with both introduced and local forage species
- changes in species composition especially woody weeds and other undesirable species
- role of burning in species composition and productivity
- management options for ponded areas
- integration of ponding banks and water spreading into catchment management.
- producer concepts on the use of the technology

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# ECOLOGICAL RESEARCH ON PLANT COMMUNITIES IN THE NORTH OF IRAN: A SITE POTENTIAL APPROACH.

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# **ABSTRACT**

The objectives of this study were to draw a map using a geobotanical approach. The combination of a plant-based and land-based approach was used to recognise the ecological factors affecting the communities. Four geomorphological units were recognised.

Soil type was determined at each site by a combination of field observation and laboratory analysis. Also, water table depths were calculated.

By using floristic and physiognomic methods in each sample area, the plant communities and vegetation units were recognised. The key plants for each of 57 communities were identified.

The vegetation density, height, growth form and ecological factors for each site for all geomorphic units were measured and recorded using numerical codes. Then, the geobotanical map of these environmental factors (land unit, soil and vegetation) was developed. This geobotanical approach to assessment of site potential offers promise for extensive rangelands in semi-arid regions to determine land capacity of these areas. It is rapid and relatively inexpensive and data does not suffer from the limitations of plant-based methods.

#### INTRODUCTION

The semi-arid rangelands of north eastern Iran have been grazed by sheep, goats and other livestock for millenia. The present day vegetation is a product of this grazing pressure but is also influenced by geomorphic, edaphic and climatic constraints.

Geobotany is an approach adopted by many vegetation scientists to help characterize the vegetation patterns. It combines geomorphology and soils with the floristics and physiognomy of the plants to create a basis for classification of land units and the vegetation they support.

This study aimed to classify and map vegetation in an area of 50,000 ha and to assess the value of the geobotanical approach as a tool for assessing site potential which combines geomorphology and soils information with the floristics and physiognomy of the plants.

#### SITE CHARACTERISTICS

The survey was conducted in the Aqala plain located in the north east of Iran (latitude 37° N) near the Caspian sea. The average annual precipitation is 230 mm and the mean annual temperature is 17°C. Rainfall is greatest is the winter months. Altitude varies from -10 to 40m and Quaternary age sediments dominate.

# METHOD AND RESULT

The approach required field surveys to assess soil and vegetation. Aerial photographs (1:20,000 scale) and existing geological and topographical maps were used to derive some information. Climatic data were obtained from meteorological stations nearby.

Maps of slope, aspect, altitude and slope direction were produced at 1:20,000 scale. Each plant community was mapped according to its cover and physiognomic characteristics. A map of land units was produced by overlaying topographic maps (slope, aspect and contour) and lithology. The data are summarized in Table 1.

Table 1. Geomorphological specification of Aqala plain.

Geomorp	hologica	.1	ological Charact	teristics				
Formation	Facies	Topography			Morphology	Lithology	Land	
		Aspect	Slope %	Altitude m			Unit	
	Hilly	North	II(2-5)	10-40	S.E. & R.E.	L & C.L.	1	
Gorgan	#	South	II(2-5)	10-40	#	#	2	
	#	East/West	II(2-5)	10-40	#	#	3	
Wind erosion sediment	Salty swamp	East- West	-(,		Salty swamp	Clay loam & gypsum with salt	4	

S.E & R.E. refer to surface erosion and rill erosion. L & C.L. refer to loam and clay loam.

Finally, a geobotanical map was prepared by overlaying the land unit and plant community in which the characteristics of each plant community were displayed with reference to a series of codes. These codes identified land-based and plant-based attributes:

Land-based: Soil salinity

Water table depth

Topography (slope, aspect & altitude)

Lithology

Plant-based: Life form

Plant height Cover density

#### **DISCUSSION**

Climatic, geomorphologic and soil attribute information are the major elements in geobotanical studies, which give a comprehensive overview of landform, soil, geology and eventually the plant community of a mapped site. This approach identifies and classifies the site according to its potential. Each plant community was found to grow at a specific site. The characteristics which determine plant distribution and composition include:

- \* Soil water storage capacity (which is influenced by topographical attributes, lithology, run off, distribution of surface water and infiltration rate).
- \* Soil fertility and depth

Soil salinity

\* Soil texture and structure

\* Depth of water table

Many of these factors influence long-term productivity and hence rangeland condition.

# **CONCLUSION**

The geobotanical approach provides a good picture of site potential, because there is a vast array of information relating to site capability. On the basis of geobotanical maps, the dynamics of vegetation cover under different management practices could be evaluated in future if a monitoring programme and reference areas are established. The major constraints such as soil degradation and topographical attributes have been identified here using land-based and plant-based measures. This approach to assessment of site potential offers promise as an aid to evaluating rehabilitation options for each plant community. Economic decisions (such as re-seeding) can be based on land capability of land site. It is rapid and relatively inexpensive and data does not suffer from the limitations of plant-based methods.

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# WIND ERODED DUST FROM DROUGHT AFFECTED LAND AT TILPA IN WESTERN NEW SOUTH WALES

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#### **ABSTRACT**

Dust concentrations and wind conditions were measured to a height of 10~m in a drought affected semi-arid rangeland. The distribution of sediment mass with height varied according to the origin of the dust storm. Locally entrained dust storms tend to have sediment distributions that are weighted towards the surface. Dust storms that are entrained further away from the site tend to have similar sediment masses with height. The mass of suspended sediment between 0.001 and 10~m height was < 0.5~kg/m width/week for most weeks but increased to 4.8~kg/m width during dust storm periods.

# **INTRODUCTION**

Wind erosion in Australia has been linked to productivity decline in the rangelands (Miles 1993). Meteorological records of dust storm occurrence in eastern Australia show that a major area of wind erosion stretches from south-west Queensland to the Mallee region in western Victoria (McTainsh *et al.* 1990). While this approach describes broadscale patterns of wind erosion frequency, it does not describe the process or the mass of soil being removed.

In 1992, Tilpa in Western NSW, was in the grip of an extended drought and large proportions of the landscape were affected by wind erosion. This study reports the preliminary results of a study at Tilpa. The aims were to describe the distribution of sediment mass with height, and the sediment mass flux of individual dust storms.

#### **METHODS**

A portable automatic micro-meteorological dust monitoring station on a 10 metre tower was used to measure temperature, wind velocity and direction, and to sample dust at 4 heights (z): 2, 4, 6 and 10 m. Dust flux estimates are made by integrating mass of dust with height between 0.001 and 10 m. Wind velocity was measured at 10 m with a cup anemometer and results recorded every 12 minutes.

# RESULTS AND DISCUSSION Dust storm type

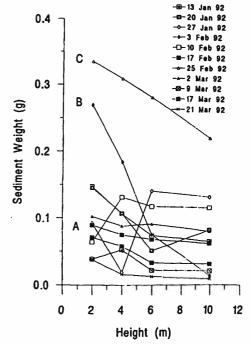


Figure 1. Sediment distribution with height for 11 weeks at Tilpa.

There are three types of dust event evident from the sediment mass with height data. In Figure 1, next to the letter 'A' is a cluster of dust profiles where there is very little change in dust mass with height. These represent the background dust levels for the site.

On the week preceding the 3 February 1992, there was a dust event from which large samples were collected at the lower two sample heights, and much less sampled at the two higher heights (Figure 1, next to the letter 'B'). This most likely indicates a local erosion event that supplied locally entrained dust to the lower samplers but there was insufficient suspended dust to reach up to the higher samplers.

On the week preceding the 25 February 1992, a large dust storm was recorded which had a linear distribution of material up the tower (Figure 1, next to the letter 'C'). This suggests a regional dust storm in which both locally derived material and distant dust were sampled.

#### **Dust Fluxes**

The point dust fluxes  $(q_a)$  for each of the four heights are calculated by equation (1) where m = mass of sediment collected,  $u_z = mass$  wind velocity at height z,  $u_s = mass$  are calculated by equation (1) where m = mass of sediment collected,  $u_z = mass$  are a sampler intake velocity,  $u_z = mass$  and  $u_z = mass$  are a of sampler intake.

$$Q_d = \left[ \frac{m \frac{u_z}{u_s}}{\frac{\Delta T \Delta A}{\Delta A}} \right] \tag{1}$$

The total dust flux (Q) between the limits of 0.001 m and 10 m are calculated using equation (2).

$$Q_d = \int_{0.001}^{10} mdz \tag{2}$$

The  $Q_d$  for the local event during the preceding week of the 3 February was 2.2 kg/m width. The  $Q_d$  for the dust storm derived from some distance away for the preceding week of the 25 February was 4.8 kg/m width. The two fold difference between the two events is a function of the sediment distribution within each event. The distant event had similar masses being transported at all heights, with only a 1.5 fold difference between 2 and 10 m height. In comparison the local event had the greatest proportion of the sediment mass near the surface with a 19 fold difference between the 2 and 10 m heights. While these dust fluxes  $(Q_d)$  seem small, when they are scaled up to the dimensions of a dust storm, the total flux rate indicates a large proportion of dust being removed from the landscape.

Future work will aim to estimate the mass of dust removed for entire dust storms, and to identify which part of the landscape is emitting the most dust so management strategies for the control of wind erosion can be formulated for high risk land units.

#### **CONCLUSIONS**

Depending on the shape of the height / sediment mass curve it is possible to gauge if the event was local or long distance. The distribution of sediment mass with height is linear for most events recorded at Tilpa. The slope of the relationship increases for larger events. The sediment flux rate (from 0.001 to 10 m) was nearly 4.8 kg/m width for one week.

# **ACKNOWLEDGMENTS**

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# A TECHNIQUE FOR CONSERVING LIMITED RESOURCES WITHIN SEMI-ARID LANDSCAPES

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# **ABSTRACT**

In semi-arid landscapes plants tend to be clumped into distinct patches where water and nutrients have been concentrated into these sinks from source areas. This source-sink phenomenon is maintained by surface-flow processes. Land utilization has often altered these processes leading to a loss of water and nutrients. One effective technique which can restore these landscape processes is to construct an obstruction to surface water flow with tree branches positioned in small elongated piles along contours. Our results demonstrate that this recreates habitats which favour the establishment of plants.

# **INTRODUCTION**

Landscapes in the semi-arid woodlands of eastern Australia are organised into source-sink systems (Ludwig and Tongway 1994). Groves of trees occur as landscape sinks that are relatively rich in soil nutrients (Tongway and Ludwig 1990). These groves or sinks concentrate nitrogen and organic carbon, and water, from upslope source areas or intergroves. Both fluvial and aeolian erosional/depositional processes are involved in these resource concentration effects. These effects also operate at scales smaller than groves-intergroves. Fallen mulga trees accumulate fluvial and aeolian materials to form log mounds that have soils with significantly higher levels of nutrients and rates of water infiltration than soils adjacent to these log mounds (Tongway *et al.* 1989). Semi-arid landscapes are organised into source-sink structures at a range of scales.

When heavily utilised for livestock production, these landscapes lose some of their ability to concentrate limited water and nutrient resources. The breakdown of natural landscape patches, such as log mounds and tree groves, by grazing results in a loss of topsoil, and vital water and organic matter resources, during run-off events. In this study we asked the question of whether elongated piles of mulga branches, aligned along the contour, would effectively concentrate water, litter and topsoil. Would this be an efficient technique for rehabilitating areas that have lost their natural patchiness. Would this also add to our understanding of the regulation of scarce resources within semi-arid landscapes.

#### **METHODS**

The study was conducted on the CSIRO Lake Mere grazing trial, located 40 km north west of Louth, NSW. Within two paddocks, one grazed (at 0.7 sheep/ha) and one ungrazed, piles of mulga branches were placed along the contours of five replicate, randomly selected transects in each paddock. Two other treatments were used to test whether the rate of rehabilitation would be increased by adding extra nutrients (each autumn at  $10 \, \text{gNO}_3/\text{m}^2$ ) and organic matter (once at  $250 \, \text{gdw/m}^2$  leaf litter). The eight factorial combinations of these three treatments were randomly applied to eight  $2m \times 5m$  plots on each of the five transects in each of the two paddocks. Soil surface elevation data and soil samples were collected at the start of the experiment in the winter of 1988 and then after three years, at which time infiltration rate was measured; foliage cover of perennial plants was observed each season.

# **RESULTS**

At the end of three years, the only significant changes were due to the mulga branches treatment (Table 1). Soil surface elevation increased over 2 mm within the branches plots (formed mounds) while those plots without branches lost elevation (eroded). In the branch plots, total nitrogen in the surface 1 cm was significantly higher, the rate of water infiltration was up to ten times higher and the five most abundant perennial grasses and one sub-shrub on the site significantly gained foliage cover through 1990 until the start of a drought in 1991.

TABLE 1. Changes in response to mulga branch treatments on plots within grazed and ungrazed paddocks on Lake Mere. Significance of mean differences between + and - branch treatments is denoted as: \* = p < .05, \*\* = p < .01. NA = data not available at this time.

	GRA	UNGRAZED		
	+ BRANCHES	- BRANCHES	+ BRANCHES	- BRANCHES
SOIL SURFACE ELEVATION (mm; 1988-1991)	+2.50	-3.30**	+2.20	-1.80*
SOIL INFILTRATION RATE (mm/hr)	1.98	0.20**	0.94	0.40*
TOTAL SOIL NITROGEN (% in top 1 cm)	0.098	0.072*	NA	NA
Aristida jerichoensis (% cover; 1988-1990)	+0.86	-0.04**	+2.20	+0.26**
Digitaria coenicola (% cover; 1988-1990)	+0.20	-0.01*	+0.21	-0.01*
Eragrostis eriopoda (% cover; 1988-1990)	+0.43	+0.03*	+4.30	+5.60
Monachathera paradoxa (% cover; 1988-1990)	+0.22	-0.68*	+0.74	-0.64*
Thyridolepis mitchelliana (% cover; 1988-1990)	+1.27	-0.93**	+7.60	+1.33**
Maireana villosa (% cover; 1988-1990)	+0.10	-0.09*	+2.87	+0.22**

#### **DISCUSSION**

This experiment confirmed that piles of tree branches will create an efficient trap for topsoil, litter and runoff water. Although general field observations suggested that piles of branches formed by lopping trees appeared to grow grasses, this experiment quantified the validity and efficacy of such piles for creating new fertile patches on bare, eroding slopes. Also, the practical implications of using readily available materials to promote the rehabilitation of eroding semi-arid landscapes are clear. The construction of fertile patches with piles of branches, which are also robust to weathering and grazing, can become part of on-going land management practice. Using this technique will insure the survival of perennial plant populations within paddocks that are utilized by grazing animals. The rebuilding of landscape patchiness for purposes of rehabilitation is in line with re-establishing the natural patterning and functioning of landscapes. This patchiness functions to conserve limited water and nutrients within semi-arid landscape systems.

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# MESOSCALE PATTERNING INDUCED BY PAST ACTIVITIES OF THE BURROWING BETTONG (BETTONGIA LESUEUR) ACROSS ARID AUSTRALIA

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#### **ABSTRACT**

We discuss the probability that the once widespread burrowing bettong, because of its fossorial activity and omnivorous diet, was an important keystone species influencing several mesoscale landscape processes in arid and semi-arid rangelands. Data on architecture, density and distribution of relict warrens are discussed in relation to bettong densities and their potential to influence these processes, particularly the biological control of native shrubs.

# **INTRODUCTION**

An examination of the size relationships of rangeland marsupials, plotted as cubed root of bodyweight against body length, reveals a distinct clumping or grouping. This phenomenon of body size clumping has recently been discussed in some detail by Holling (1992) who argued that not only did the geometry of landscapes shape the morphology of animals but that key organisms, together with abiotic disturbances, in turn shaped the geometry of ecosystems. In particular, he claimed that the direct impacts of grazing by herbivores, together with disturbance processes such as fire, insect outbreaks and water flow, dominated the formation of mesoscale patterns (100s of metres to 100s of kilometres) over time scales of years to decades.

In this paper, we will discuss the probability that the once widespread burrowing bettong (Short and Turner 1993), because of its fossorial activity and omnivorous diet, was an important keystone species or 'driver' of biodiversity influencing several mesoscale landscape processes in arid and semi-arid rangelands. Observations on architecture, density and distribution of relict bettong warrens in western New South Wales will be discussed in relation to putative densities of burrowing bettongs and their possible impact on landscape processes, particularly the biological control of native shrubs.

#### WARREN CHARACTERISTICS AND POPULATION ESTIMATES

The morphology of relict bettongs warrens is generally characterised by a horseshoe-shaped mound up to 30 metres in diameter surrounding a central depression excavated by past burrowing, often with entrances located beneath an exposed limestone or calcrete stratum (Noble 1993). Results of recent excavations of selected warrens at "Lake Mere", 35 km north of Louth, NSW, suggest that at some stage in the past, burrowing bettongs have deliberately selected subterranean calcrete domes rising from a deeper calcrete sheet at c. 80 cm depth to within 10 cm of the soil surface.

When viewed from the air, these features appear to follow a distinct linear pattern, often running parallel to drainage lines. In what appears to be a two-stage process, the calcrete dome has been first exposed enabling the bettongs to then locate peripheral weaknesses or zones of soft calcrete enabling them to tunnel beneath the capping. Past entrances, and directions of the tunnel drive, can be identified by the location of secondary deposits of white calcrete overlying the brown soil first removed from above the calcrete dome.

In October, 1993 an area of 5 sq km on "Lake Mere" was surveyed from the ground by traversing parallel transects at 50 m intervals and recording the positions of all visible bettong warrens using a global positioning system (GPS). Size (mean diameter) and class of each warren were also noted. A total of 36 warrens were located within this area giving a warren density of c. 7/sq km. Because the majority of warrens were located in only half this area on massive red earths as distinct from the remaining area of sandy red earths, warren density was probably doubled to 14/sq km in 'preferred' habitats.

Using bettong population densities of c. 14-17/sq km established by Short and Turner (1993) for Bernier, Barrow and Dorre Islands in Western Australia, a putative population size of 70-85 bettongs

might be postulated for this sample area on "Lake Mere" based on an average colony size of 2-3 bettongs per warren. Such estimates however may be unduly conservative since colonies of 50-70 bettongs per warren have been recorded elsewhere (Seebeck *et al.* 1989). Given that the environment in the three WA islands is considerably more arid (200 mm at Barrow Island cf. 300 mm p.a. at Louth), increasing average colony size to just ten would increase population size at "Lake Mere" by an order of magnitude to around 700 bettongs or 140/sq km conservatively.

#### LANDSCAPE PROCESSES

Because the burrowing bettong originally had the widest distribution of any marsupial in Australia, it is germane to consider what landscape processes, if any, have been adversely affected in the rangelands following their mainland extinction. Burrowing bettongs clearly had a significant influence in terms of patch dynamics and nutrient cycling with discarded warrens acting as fertile 'islands' with surface soil and organic matter, including seeds, being trapped in the central depression. Whether mycorrhizal fungi, similar to those eaten by related potoroids in more humid ecosystems (Claridge et al. 1992), were dispersed by the burrowing bettong together with seeds of certain herbs and shrubs, is still to be determined. One of this animal's most important landscape functions however may have been to regulate seedling recruitment by native shrubs (Eremophila, Cassia and Dodonaea spp.), similar to the control of mesquite (Prosopis spp.) recruitment by the prairie dog (Cynomus ludovicianus) in Texan rangelands (Archer 1993).

#### **CONCLUSION**

The recognition, after only two decades of pastoral settlement by Europeans, that there was a significant 'woody weed' problem developing in western New South Wales, also coincided with the rapid demise of the burrowing bettong. Whether there is any definite causal relationship between the two has still to be resolved. Given this background though, we conclude with the hypothesis that this animal had a fundamental role in mediating several mesoscale landscape processes in Australian rangelands.

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# THE NATIVE PASTURES OF THE EUCALYPT WOODLANDS OF INLAND CENTRAL AND SOUTHERN QUEENSLAND

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QDPI: 1Emerald and 2Roma

#### INTRODUCTION

The native pastures of the eucalypt woodlands of inland central and southern Queensland support an active pastoral industry but in terms of botanical composition have been inadequately documented. For long term and sustainable pasture management, graziers require more information about the pasture species indicative of changing pasture conditions.

Detailed vegetation descriptions for much of the area are lacking. Weston (1981) mentions grass species most likely to occur within this community. Tothill and Gillies (1992) describe three pasture condition classes (A, B and C) using grass species as indicators and while the survey of Schefe *et al.* (1993) describes the ground cover floristics of the land types in the Maranoa it does not provide the detail required to describe the complexity of the woodland pasture community.

In Central and Southern Queensland, this native pasture community is commonly referred to as Aristida/Bothriochloa. Rainfall is summer dominant and the annual average varies from 600 mm in the south (Maranoa) to 700 mm in the north (Central Highlands). Soil fertility is generally low, and soil types include light clays, duplex, deep sands and lithosols. The major overstorey types are narrow-leaf ironbark (Eucalyptus crebra), silver-leaf ironbark (E. melanophloia) and poplar box (E. populnea), with cypress pine (Callitris glaucophylla) dominant on the deep sands. Understorey species include Petalostigma pubescens, Eremophila mitchellii and Acacia spp.

In this paper preliminary pasture survey results are presented and some trends and contrasts in species composition are highlighted. Data were collected during the summer of 1993, and these interim results will be supplemented by future surveys. This work is part of a larger study described by Filet and Hall (this volume).

# PASTURE COMPOSITION

The surveys indicate that *Chrysopogon fallax* and *Heteropogon contortus* are very common, though not necessarily dominant, in the Central Highlands. *Heteropogon contortus* is however, much less frequent in the Maranoa.

In the silver-leaf ironbark woodlands the most common and dominant species were *Bothriochloa bladii*, *B. decipiens*, *B. ewartiana*, *C. fallax*, *Eremochloa bimaculata* and *H. contortus*.

Within the narrow-leaf ironbark communities *H. contortus* and *C. fallax* were the most common species, with *B. decipiens*, *C. fallax*, *E. bimaculata*, *H. contortus* and *Enneapogon* spp. most often occurring as dominant species. *Aristida calycina* also occurred at many sites.

In the poplar box woodlands *C. fallax* and *B. decipiens* were most common with *C. fallax* and *Fimbristylis dichotoma* being most often dominant within sites. *Aristida* spp., *Enteropogon acicularis*, *Eragrostis* spp., *E. bimaculata* and *H. contortus* also occurred at many sites.

#### FACTORS INFLUENCING PASTURE COMPOSITION

Overstorey competition, fire and grazing pressure have a noticeable effect on the botanical composition of the eucalypt woodland native pastures, as do climatic conditions and soil types.

In the Eucalypt woodlands of the Maranoa, pasture composition is influenced by soil texture and fertility. There is a higher frequency of *Neptunia gracilis*, *Dichanthium sericeum*, *A. leptopoda* and *Astrebla lappaceae* on the heavier textured (light clay) soils, whereas on the lighter textured (sandy loam) soils *F. dichotoma*, *A. contorta*, *A. calycina* and *E. bimaculata* occur more frequently. *E. molybdea*, *B. decipiens* and *Brunoniella australis* have a higher frequency of occurrence on medium

textured (clay loam) soils. Within the medium textured (clay loam) soils, sites with lower basal area (as low as 0.8%) have a higher frequency of *A. caput-medusae*, *E. lacunaria* and *Cymbopogon refractus* compared with sites of higher basal area (up to 3%) where *A. jerichoensis*, *E. molybdea* and *B. decipiens* occur more frequently. Within the heavier textured (light clay) soils, sites with lower basal area (down to 1.5%) have a higher frequency of *A. leptopoda* whereas sites with higher basal area (up to 3%) have a higher frequency of *Chloris divaricata* and *Digitaria divaricatissima*. Pastures with lower basal area occur on inherently less fertile soils or may be in a weakened condition due to a history of high grazing pressures.

Trends from silverleaf ironbark areas indicate that clearing promotes *H. contortus* and *Aristida* spp., but generally does not affect *B. bladii* or *B. decipiens*. Clearing in some narrow-leaf ironbark areas appears to have the same effect, except that *B. decipiens* tends to disappear. Other species preferring disturbed soils such as *Eriachne* spp. and *Digitaria* spp. start to appear following clearing, particularly if grazing pressure is low. The frequency of *C. fallax* in poplar box woodlands does not appear to change whereas *Eragrostis*, *Sporobolus*, *Chloris* and *Eremochloa* species begin to dominate after timber treatment.

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### SCALDED? TRY THIS! WATERPONDING

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#### **ABSTRACT**

Bare, scalded semi-arid areas of Australia are being transformed into productive grazing lands thanks to the environmentally proven waterponding technique which is returning clear profit to the landholders.

The Nyngan S.C.S. District since 1985 has taken the waterpond method from a struggling reclamation technique to a now standard scald rehabilitation technique that is being used Australia and world wide.

Waterponding covers three technical aspects; laser surveying, bank construction with a road grader and seeding of waterpond banks.

### INTRODUCTION

Removal of native vegetation from the semi-arid soil by drought and over utilisation has been accelerated by wind and water erosion of the red duplex soil and this has left a bare environment called scalds or clay pans.

A 3 mm crust on top of the exposed clay subsoil prevents both water penetration and lodgement of wind-blown seed.

Many methods have been tried to bring scalded country back into production but nothing has worked as well as waterponding.

Waterponding is the holding of water on the scald in horse-shoe shaped banks covering about 0.4 of a hectare each.

Each pond has a bank length of approximately 240 metres and retains up to 10 cm of water after rainfall.

The ponded water tends to leach soluble salts from the scald surface. This improves the remaining soil structure, inducing surface-cracking, better water penetration and entrapment of wind blown seed.

The increase in native pasture yield has made the waterponding technique an economic method of raising production.

# **SURVEY**

Waterponds are surveyed with a spectra-physics laser leveller mounted on and within a dual cab 4WD vehicle. When the waterpond position is being surveyed it is marked on the scald by a vacuum tine marker which is attached to the back of the vehicle. This surveying and marking unit allows one person to survey and mark over one hundred waterponds a day, ready for the construction phase to begin. The equivalent to one day's survey is two day's construction.

#### CONSTRUCTION

Road graders above 150 HP have been shown to be the most economical machine for waterpond bank construction. Waterpond banks should be constructed to a height of 45 cm and basal width of 1.8 metres to account for wave action, stock trampling, tunnelling, flooding and settlement of bank.

In most soil conditions banks can be constructed by a road grader making three passes; one pass on the inside and two passes on the outside.

When building waterponding banks with road graders there are a number of techniques which can be used to increase efficiency of operation. These are by using wheel lean, articulation and the differential lock.

Blade position is a critical factor in building ponding banks.

The completed bank is dome shaped with a single crest which allows water to run down the sides of the bank.

Waterpond bank survey is commenced from the highest part on the scald slope to ensure containment of water within successive rows of ponds. However, the construction phase should begin with the bottom row of the ponds on the scald slope as this allows efficient turning by the grader and allows the ponds to be constructed close together.

This is the opposite to the general rule in soil conservation earthwork construction which dictates that construction should always commence at the top of the slope to protect the works should rain occur during construction.

Sharp curves should be avoided in waterponding banks as the grader will not be able to produce a single crested bank of design height and cross-sectional area in tight corners. Bank construction should only be undertaken when the soil is dry enough to allow material to flow freely off the blade. The blade should always be full during construction so that the same amount of material is placed in all sections of the bank.

No loose soil should be lost under the blade during construction.

#### SEEDING OF BANKS

Waterponded areas normally take about five years to become productive. Reseeding the banks has the potential to reduce this time to three years or less depending on seasonal conditions.

Reseeding has the advantage of not only accelerating reclamation of ponds, but also improving pond pastures by the introduction of drought tolerant perennial species.

Sowing of waterpond banks is carried out simultaneously with construction. Janke precision seed boxes are mounted on the rear toolbar of the grader. Seed is sown during the inside pass along the inside batter of the bank just above natural ground level.

# COSTS

The cost of bank construction varies according to the cost of grader hire. With a grader over 150 HP hired at \$87.00 per hour the cost of banking is \$35.00 per hectare.

Cost of seeding the bank with Atriplex nummularia (oldman saltbush) seed is \$4.00 per hectare.

A total cost for construction and seed is \$39.00 per hectare or \$16.00 per waterpond.

# **FUTURE**

Waterponding has been carefully evaluated and is a sound solution to the scald problems throughout semi-arid Australia.

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#### MONITORING SOIL SURFACE CONDITION

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#### INTRODUCTION

Previous methods for assessing soil condition concentrated on looking for signs of erosion. As each soil had a characteristic way of expressing the effects of erosion, it was difficult to produce a consistent, unambiguous set of criteria with which to judge the severity and/or extent of erosion for the wide range of soils encountered in rangelands. In addition, assessments were done at random, without any landscape position or patch-type stratification so that data collected were quite variable, and difficult to interpret.

Tongway and Smith (1989) investigated a number of features directly observable in the field which were shown to be indicators of productive potential, but their studies were restricted to a single soil type and landscape location. Recent research which has been looking at landscapes in a more holistic fashion, identifying patterns and processes intimately involved in basic ecosystem function has permitted a more generic interpretation of ecosystem function to be made (Tongway and Ludwig 1990, Ludwig and Tongway 1993, and Tongway and Ludwig, 1994).

# THE NEW APPROACH

The research had indicated that all landscapes in good condition were spatially patchy in nature, and the patchiness was expressed as associations of terrain features, soil properties and vegetation distribution. Further, it was shown that patchiness was not random, but organized into recognizable pattern by the action of transport processes operating over time, depleting soil and litter from certain places in the landscape and depositing them in others. This is analogous to Pickup (1985), describing coarse-scale erosion in terms of source and sink zones, but in our studies this type of process was seen as an integral part of normal ecosystem function, particularly in respect of water redistribution across landscapes. Clearly, the pattern is most strongly expressed along the environmental gradient of slope. Alternating sequences of run-off/run-on can be clearly discerned, using the association of terrain, soil and plant species as pattern identifiers.

By adopting this approach, the balance between processes responsible for patch presence and maintenance can be deduced. For example, aeolian processes are important in landscapes with coarse non-cohesive soils and a plant density which permits wind to move particles, while water transport dominates sloping terrain with soil of low permeability. These processes may operate at a range of scales from fine (say 0.5 to 5m) to coarse (say 100m+), and nested sets of pattern at a range of scales may be present at a given site. **Becoming aware of and describing landscape pattern is the first step or stage in the new method.** Degradation can be defined in terms of a loss of pattern elements at a particular scale, because it implies that some processes are no longer functioning at appropriate effectiveness. This can be detected by changes in the size and location of source and sink patches along a given transect. Degradation would be inferred if source patches became larger or more numerous and sink patches became fewer and/or smaller. This is a simple matter of preparing a log or map of landscape zones and observing its change over time.

# SOIL SURFACE CONDITION ASSESSMENT

A finer scaled observation is the condition or status of soil in the respective landscape patch types. At this scale, and for this purpose soil is best regarded as a habitat for plants, so favourable properties are high water infiltration rate and storage capacity, high nutrient status and cycling efficiency, and resistance to erosion. A given soil site loses habitat favourability when one or more of those properties decline. By association analysis, and plant productivity studies, a range of surface soil features can be defined which give insights into habitat favourability. Each soil differs as to its absolute favourability: **this method assesses the changes which can be discerned and interpreted within a given soil type.** Moreover, each soil degrades in a characteristic way which can be described by its response to stress, as shown by changes to the surface features. Again, surface processes can be inferred from the features observed. There are 11 features which make up the soil condition data set.

Each is classifiable into one of a number of classes, for which criteria are specified in the manual, (Tongway 1993) and illustrated with photographs. In addition, the processes implied by changes in the features are explained.

	Feature	classes	Feature	classes
(1) (2)	rainsplash protection overland flow obstruction	(1-6) (1-6)	<ul><li>(6) eroded materials</li><li>(7) litter cover</li></ul>	(1-4) (1-12)
(3)	crust broken-ness cryptogam cover	(1-4) (1-4)	<ul><li>(8) microtopography</li><li>(9) crust hardness</li></ul>	(1-5) (1-4)
(5)	erosion features	(1-4)	<ul><li>(10) slake test</li><li>(11) surface texture</li></ul>	(1-4) (1-4)

Not all soils will yield useful data from every feature. With experience, only the most useful or variable features need be retained. In the first place, however, each feature should be carefully evaluated. The data can be accumulated into a simple sum, because in every case, the higher the class value, the more favourable the soil attribute. Or alternatively, the data can be grouped so as to look specifically at infiltration, stability and nutrient status. The manual explains how the groups are constituted. This process also assists the user in that the soils weaknesses and strengths are highlighted, and the soil's performance assessed in terms of processes.

The soil assessment process does require some commitment to learn, but with experience becomes quite quick, and is constantly informative to the assessor.

The technique was originally devised for use in Mulga woodlands, Chenopod shrublands and Eucalypt woodlands. It has been used in tropical and sub-tropical woodlands and grasslands without problems. Being based on pattern and process, it has inherent rigour, and is usable in a wide variety of rangelands.

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#### SOILS OF THE NORTH-EASTERN GOLDFIELDS. WESTERN AUSTRALIA

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The soils of the north-eastern Goldfields were described during the regional resource survey conducted by the Western Australian Departments of Agriculture and Land Administration, as reported in H.J.R. Pringle, A.M.E. Van Vreeswyk and S.A. Gilligan, (1994) 'An inventory and condition survey of rangelands in the north eastern Goldfields, Western Australia,' Technical Bulletin 87, Department of Agriculture, Western Australia.

Characteristics of the major soils types and their position in the landscape are discussed.

Deep earthy red sands occur on extensive sandplains supporting spinifex hummock grasslands. They may be susceptible to wind erosion after fire.

Lithosols are stony, shallow soils on hills and breakaway plateaux. They support very sparse sclerophyllous vegetation. Lithosols are usually protected from erosion by coarse fragments on the surface.

Calcareous red earths occur on slopes below greenstone hills. They support calciphytes such as jam (Acacia burkittii) and pearl bluebush (Maireana sedifolia). Slopes are susceptible to water erosion. Red earths are acid loamy soils. Shallow red earths overlying hardpan occur on extensive plains receiving sheet flow. These soils support mulga with sparse understoreys. Severe erosion may expose the hardpan.

Duplex or texture-contrast soils occur on saline alluvial plains and on footslopes below breakaways. They support saltbush and bluebush shrubs. Duplex soils are highly susceptible to erosion when vegetative cover is removed. Loss of topsoil by wind or water erosion leaves bare unproductive subsoil.

Red and brown clays occur locally on highly saline alluvial plains and drainage features such as claypans. They support a range of vegetation including samphire (*Halosarcia*) and perennial grasses such as claypan grass (*Eriachne flaccida*). These soils are generally stable.

The outstanding characteristics of the soils of the north-eastern Goldfields are their predominantly red colour and the widespread siliceous hardpan. In the south-west, the influence of calcrete is prevalent. Stony mantles and shallowness are also dominant features.

The loss of vegetative cover resulting from overgrazing may lead to accelerated erosion in susceptible areas.

# PROSPECTS FOR THE REGENERATION OF ARID WOODLAND TREES IN THE RANGELANDS OF SOUTH EAST AUSTRALIA

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#### **ABSTRACT**

An investigation has been made of the regeneration characteristics of nine arid woodland tree species, Casuarina pauper, Alectryon oleifolius, Myoporum platycarpum, Geijera parviflora, Callitris glaucophylla, Hakea leucoptera, H. tephrosperma, Acacia melvillei and A. loderi, all of which are valuable for shade, shelter and forage. Studies undertaken in glasshouse conditions and at 250 sites subjected to various grazing regimes in NSW, SA and Victoria suggest that suitable conditions for successful regeneration occur infrequently but that grazing by stock, feral animals, rabbits and increased populations of macropods has prevented widespread establishment even after these rare events. This has serious implications for the long term future of the pastoral industry. Data are presented on the natural regeneration characteristics including the significance of seed and suckers, the significance of episodic events, and the effects of management options including stock exclusion, clearing, mechanical disturbance and fire. Prospects for long term regeneration are reviewed.

# **INTRODUCTION**

Widespread concern has been expressed regarding the lack of regeneration of trees and shrubs in the arid and semi-arid rangelands of south east Australia. The grazing pressure that has been exerted over most of the land for up to 150 years, coupled with the episodic nature of natural regeneration, means that many communities are seriously at risk. Both pastoralism and conservation depend on the long term survival of the natural perennial vegetation. A study has been undertaken into the ecology and conservation status of a number of species of concern; *Myoporum platycarpum* (Sugarwood), *Casuarina pauper* (Belah), *Callitris glaucophylla* (Cypress pine), *Geijera parviflora* (Wilga), *Hakea leucoptera* (Needlewood), *H. tephrosperma* (Hooked Needlewood), *Acacia loderi* (Nelie), *A. melvillei* (Yarran) and *Alectryon oleifolius* (Rosewood). Studies extended over an area of south east Australia; in South Australia, Victoria and south western New South Wales, including both pastoral leases and conservation reserves.

# **METHODS**

- 1. The original structure and composition of the arid woodland communities were determined by reference to examples which have been subject to relatively low grazing pressure;
- 2. The age structure and regeneration history of these species under differing grazing regimes were assessed by analysis of stem diameter histograms.
- 3. The regeneration characteristics were studied through field observation and laboratory and glasshouse trials;
- 4. Exclusion plots have been established to study long-term regeneration in the absence of grazing.

# **RESULTS**

Analysis of these communities at 250 sites across the study area demonstrates that all have the potential to develop a diverse shrubby understorey but that in many instances this understorey is severely depleted by grazing. The communities had a relatively consistent structure throughout the study area and apparent variations relate mainly to differing grazing histories.

Assessment of stem diameter histograms from 250 sites with a varied grazing history indicate that areas subjected to heavy long-term grazing have shown little or no regeneration for the past 100 years. This is particularly true of grazing licences in north west Victoria and large areas on pastoral leases

in south west NSW and the north east of SA. Where grazing pressure has been lighter on certain pastoral leases in NSW and SA, or where the communities have been protected within conservation reserves since the high rainfall years of 1973/74/75, extensive regeneration has occurred. Regeneration is particularly prolific where there has been major soil disturbance prior to good rains.

Assessment of reproductive strategies in the field indicates that despite the age and senescence of many of the remaining trees, flowering and fruiting is prolific with large quantities of seed produced in most years.

Laboratory trials indicate that for most of the species seed viability is adequate and remains so for at least twelve months. These results combined with high seed production will ensure the availability of viable seed when soil conditions are suitable for germination.

Simulated grazing trials under glasshouse conditions showed that young seedlings vary in their tolerance to partial and complete defoliation.

Past efforts to improve grazing values within arid woodlands through chaining have modified the communities and in particular may lead to an increase in woody weeds.

#### **CONCLUSION**

Successful regeneration of these arid woodland species depends on:

- (i) high moisture availability over two successive years;
- (ii) availability of viable seed;
- (iii) low grazing pressure to allow establishment of seedlings.

Only the latter two factors can be manipulated. Examination of records suggests that major rainfall events of the type required have only occurred three times since settlement. It is too soon for exclusion plots established in N.W. Victoria and S.W. NSW to show clear cut results, but an above average rainfall in the area since September 1992 may be providing the opportunity for regeneration of overstorey and associated understorey species. However, even following high rainfall events of this type, widespread regeneration is unlikely without significant reduction in grazing pressure. Future changes in the pastoral industry brought on by low wool prices may provide this opportunity.

# **ACKNOWLEDGEMENTS**

We would like to thank in particular Trevor and Mignon Brown of Tarawi Station, NSW for their hospitality and friendship during many field trips. Also numerous other pastoralists for access to study sites and sharing their knowledge, staff of land management agencies for freely giving advice and assistance and finally to the R.I.R.D.C. and the W.W.F. without whose financial support this study would not have been possible.

#### THE IMPACT OF THE REPLACEMENT PHILOSOPHY ON THE RANGELANDS OF AUSTRALIA

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#### **ABSTRACT**

The dramatic success of exotic clovers and grasses plus fertilisers in increasing carrying capacity in the higher rainfall zones of Australia in the 1940s and 1950s has coloured the thinking of a generation of scientists and land managers. We tend to look overseas for plant species for a whole range of purposes rather than among our native flora - the replacement philosophy.

The replacement philosophy has led to the introduction of numerous agricultural and environmental weeds and rangeland scientists and managers must be made aware of the dangers associated with plant introduction. We need to make far more effective use of our Australian flora for commercial purposes.

#### INTRODUCTION

Two contrasting attitudes to the vegetation of Australia were apparent from the earliest days of European settlement. Surgeon White of the First Fleet wrote, admittedly during a period of intense depression, "There was not a single article in the whole country that in the nature of things could prove of the smallest use or advantage" (White 1962). On the other hand, others wrote enthusiastically about the many new plants and animals that they encountered. Considerable time and effort was spent looking for commercial plant products amongst the Australian flora.

The practicalities of living in the new land led to the beginnings of agriculture and the grazing industries. Agriculture, of course, was based on introduced crops while the early grazing industries were based on native rangeland species. The appearance of weedy species in pastures was recorded quite early in the pastoral development of Australia (Gardner 1854).

# PASTURE IMPROVEMENT IN AUSTRALIA

Systematic plant introduction commenced early in the 20th century by agencies such as the then NSW Department of Agriculture. The original Plant Introduction Register at the Trangie Agricultural Research Station contained entries from about 1915. By the mid 1930s the technology of the introduction of sown grasses and clovers together with additions of superphosphate was well established on the Tablelands.

The development of aerial agriculture in the late 1940s together with subsidised superphosphate and the very high wool prices of the early 1950s led to a massive increase in pasture improvement over the next two decades. The whole emphasis of the pastoral industries was on the replacement of native herbaceous species with exotic grasses and clovers. The success of this approach and economic dependence on the wool industry coloured the thinking of a nation. If we needed a species of plant for a specific purpose, then we looked overseas rather than among our native flora - the "replacement philosophy". This philosophy is exemplified by the book "Pasture Improvement in Australia" edited by Barry Wilson in 1968. The chapter on New South Wales lists exotic pasture species adapted to each district and the only mention of native species is for the Western Division. An overwhelming preponderance of pasture research papers published during the 1960s in Australian journals dealt with exotic rather than native species (Whalley 1970).

#### **IMPACT ON RANGELANDS**

The massive introduction of exotic plants into Australia has had a major impact on the vegetation. Of 233 exotic noxious weeds in Australia, nearly half were introduced deliberately (Panetta 1993). The impact on the native rangeland species in southern Australia has been disastrous and only tiny remnants of once widespread plant communities survive (Stuwe and Parsons 1977). The continued existence of these remnants is precarious indeed under present land management.

It is impossible to know how many deliberate introductions of exotic pasture species occurred in southern Australia, what proportion of them were valuable and what proportion have become agricultural or environmental weeds. Lonsdale (1994) reported that between 1947 and 1985, 2,033 separate accessions of grasses and legumes were introduced into northern Australia. Of the 463 species introduced, only 21 were recommended as useful but 60 species became weeds. Of the 21 useful species, 17 were considered weeds in some situations leaving only four species which were useful but not weeds (Lonsdale 1994). The record in southern Australia was probably not much different.

# THE FUTURE

The impact of agricultural, rangeland and environmental weeds is increasing. It is vital that we all recognise that the replacement philosophy is part of our culture and make conscious efforts to discard it. We must examine carefully the Australian flora, both native and naturalised whenever we need a species for a specific purpose and only introduce new plants as a last resort. Panetta (1993) has proposed a system of assessing the weed potential of plant introductions and this approach must be refined and used to minimise the risks associated with future plant introductions. Above all, we need to educate a wide range of land managers and the general public about the consequences of the replacement philosophy.

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# PASTURE IMPROVEMENT, PLANT PRODUCTIVITY AND ANIMAL PRODUCTION

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# FINDING BACKUP LEGUMES FOR STYLOS

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#### **ABSTRACT**

Grazing systems based on the *Stylosanthes* cultivars are becoming more important and more used for increasing and sustaining beef production in northern Australia. Seca stylo (*S. scabra*) is the best adapted and most used legume with seed production around 150 to 200 tonnes per year. However this reliance on the stylos, and Seca in particular, could jeopardise the long term substainability of legume-based grazing systems if the increasing incidence of disease or insect attack destroyed current cultivars. A new project aims to release new non-stylo legumes to "back up" and complement the stylos and provide technology packages to quickly integrate them into the grazing industry. A network of adaptation, grazing evaluation and nutrition sites cover the 600 to 1000 mm rainfall zone of northern Australia on soils suitable for growing stylos.

#### INTRODUCTION

The lack of alternative well adapted legumes to back up the *Stylosanthes* cultivars should be of concern to both cattle producers and researchers in northern Australia where the potential for pasture development is great (Walker 1991). The stylo cultivars now dominate pasture legume sowings. Seca (*S. scabra*) is the main stylo sown with seed production estimated at 150 to 200 tonnes per year (J.M. Hopkinson, pers. comm.). A significant increase in sowings occurred during the late 1980's, particularly in central Queensland, as the remarkable adaptation of Seca stylo to climate and soils and its contribution to liveweight gain was demonstrated in grazing trials and producer demonstration sites.

The development of productive and sustainable pastoral systems is the objective for future pasture development (Walker 1991). There is a need to find improved and alternative legumes to counter the increasing importance of major diseases and pests on the persistence of current legume cultivars (Gramshaw *et al.* 1989). Although work is in progress to develop cultivars of *Stylosanthes* with resistance to anthracnose (*Colletotrichum gloeosporioides*) (Irwin 1989), there is also a strong need to find new alternative back-up legumes for the stylos.

# THE PROJECT

A research project was commenced in 1992 to find back-up legumes for stylos. Managed by the Queensland Department of Primary Industries and involving the Northern Territory Department of Primary Industries and Fisheries, CSIRO Division of Tropical Crops and Pastures and James Cook University Department of Botany and Tropical Agriculture, the project receives financial support from the Meat Research Corporation. Target soils are the lighter acid soils most suitable for stylo growth. Target rainfall is 600 to 1000 mm. The main objective of the project is to ensure a sustainable, productive and profitable beef industry in northern Australia by:

- \* releasing new legumes to "back up" and complement present stylo cultivars
- \* understanding the growth, production, fertiliser requirements, plant mineral concentrations, seed production, grazing management and animal liveweight gain of these new legumes
- \* bringing the new legumes quickly into use by the grazing industry.

A network of twelve adaptation sites, three liveweight gain sites and three phosphorus response sites is established across northern Australia from Gayndah in South-east Queensland to Katherine in the Northern Territory. Adaptation of legumes is tested in large plots (100 to 1000 m²) under grazing by measuring compatibility with native and sown grasses, grazing acceptability and persistence. Separate sites measure contribution to liveweight gain from advanced legume lines. Field sites are defining the phosphorus responses, nutrient concentrations in the plant and the soil phosphorus requirements of these new legumes relative to Seca stylo.

# RESULTS AND DISCUSSION

Below average rainfall at most sites in the first (1992-93) season indicates best tolerance to low rainfall from *Aeschynomene brasiliana*. *A. histrix* and *Chamaecrista* (*Cassia*) rotundifolia also established under harsh conditions. The perennial *A. americana* cv Lee may be a productive legume in rainfall zones down to 800 mm in areas with a winter rainfall influence due to its perennial growth habit taking advantage of a longer growing season. Glenn jointvetch, being an annual, relies on summer rainfall only and is recommended for 1000 mm rainfall areas. Similarly perennial lines of *A. villosa* are performing well in south-east Queensland. Preliminary data indicate *A. americana* and *A. villosa* yield are more responsive to phosphorus rate than is Seca stylo. The *A. villosa* and *A. brasiliana* grazing evaluation sites to monitor grass-legume composition as well as liveweight gain are now stocked. Due to attributes of persistence under dry conditions and tolerance to cold winter temperatures, a range of *Desmanthus virgatus* lines have been sown at our network of sites in the 1993-94 season to evaluate them for adaptation to light acid duplex soils. Several lines show early promise.

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#### DATABASES FOR MODELLING OF RANGELAND SYSTEMS

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#### **ABSTRACT**

This poster describes two methods for synthesising relevant plant, animal and environmental data, available in often large trial data sets, into summary form. Utilising observation codes, dates and a modern text editor, data can be easily stored and manipulated. The organisation of data in this way enables a whole system approach to be used in analysing data sets, and allows linking of data sets for validation of parameters used in computer models, such as the QDPI's GRASP pasture growth model.

# INTRODUCTION

The QDPI's GRASP (GRASs Production) pasture growth model (McKeon *et al.*, 1982) has been developed to model native pasture production systems under grazed and ungrazed conditions and also is being developed as a near real time spatial model to enable monitoring, assessing and predicting the future of Queensland rangelands (Carter *et al.*, 1992).

In Queensland data sets exist from grazing trials, pasture manipulation trials and pasture phenological studies. These data include measurements of the main plant parameters of each land system, as prescribed by the GUNSYND program (McKeon *et al.*, 1990), for calibration of GRASP. The data also include historical grazing trial information and other pasture production measurements (for validation of GRASP) on the major native pasture communities. This paper describes formats used to summarise these data for use in GRASP or for storage and future analysis.

#### **DISCUSSION**

Data are entered using any modern text editor. Numerical record codes identify each record and link it with GRASP. Record types can be measurement (e.g. kg/ha) or action (e.g. change stocking rate). A reset code is used for the initial measurement of a variable affected by a significant management event, such as a change of stocking rate or stock type, and a corresponding observation code used for measurements during the management period. Some data types do not have reset codes because they are affected by some other data, for example animal intake which is affected by measurements of available forage. Action codes indicate the type and scope of stock or pasture management actions (e.g. stocking or fertiliser rate).

Two formats have been used to summarise data sets. The first has the form:

Comment	Date	Code	Var 1	Var2	Var3	Var4	Var5.
For Example:							
			Soil moisture		TSDM	%green	%N
			Layerl	Layer2	Kg/ha	cover	TSDM
P179	19790608	15observatio	00.00	00.00	4254.0	45.6	00.00

This format defines variables as columns and the treatment or paddock as rows. The date (08/06/79) is presented backwards for ease of sorting and the record code (15) is the defined GRASP code for this record. Variables in the above example are soil moisture at 2 operator defined levels, yield and percent nitrogen of total standing dry matter yield (TSDM) and percent green cover. Each treatment/paddock is a separate file.

The second, and more user friendly, format is to define each row to represent a single variable at a particular date and the columns to be the treatment/paddock. This is a table format, as seen in published papers, and allows for multi-treatment trials to be summarised into a single compact file.

### Format is:

Comment Date For example:		Code	Acronym	Treatments			
•				TRTO.1		TRT0.4	
Eastwood Buffel 196	880307	51	DM YLD	558.0	1447.0	1705.0	1227.0

In this format the initial comment still defines the trial and the date is still entered backwards. The record type number is 51 and this is described by the acronym DM\_YLD (total dry matter yield [kg/ha]). Action codes are used to describe the treatment. An example is a stocking rate (sheep/ha) trial with sheep (DSE = dry sheep equivalent, 1 = Merino wether):

Eastwood Buffel	19670928	290	SET_SR	10	5	2.5	1.25
Eastwood Buffel	19670928	292	DSE	1	1	1	1

Regardless of format used, the file header describes trial or paddock management details and the meaning of acronyms used for parameters (e.g. DM\_YLD) and treatments (e.g. TRT0.1).

Record types in the first format are coded for, and are currently being used for, GRASP validation. Record types in the second format have been used to summarise a majority of the data sets existing for sheep grazing and pasture manipulation/phenology studies gathered from western Queensland over the past 50 years. With the collaboration of the original authors, data have been collated from original data sets, reports and published papers and theses. Data stored in this format are a compact trial summary and are easily manipulated into the first format for use in GRASP. In the future, the second format will be accessed directly by GRASP.

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# VARIATION IN THE COMPONENTS OF SEED YIELD AND GERMINATION REQUIREMENTS AMONG THREE ACCESSIONS OF MICROLAENA STIPOIDES

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#### **ABSTRACT**

The seed production and components of seed yield of three accessions of the yearlong green perennial native grass *Microlaena stipoides* were measured over one growing season. The final seed yield did not differ significantly among accessions although there were differences among them in the way that total yield was partitioned. The accession which produced the greatest number of inflorescences produced the fewest number of spikelets per inflorescence while the accession with the least inflorescences per plant produced the greatest number of spikelets per inflorescence. Germination data showed that later maturing seed had a greater after-ripening requirement than seed produced early in the growing season and that the germination response of intact spikelets differed from that of naked caryopses.

#### INTRODUCTION

Microlaena stipoides is widespread in the temperate south-eastern parts of Australia. It possesses many features which make it a unique and desirable grass for pasture, turf and amenity purposes (Lodge and Whalley 1989, Munnich et al. 1991). The high digestibility and protein content (Archer and Robinson 1988) contribute to the high forage value of microlaena and its ability to grow in low light conditions and tendency for rhizomatous growth makes it very attractive as a turfgrass. The relatively short growth habit also makes it an ideal species for use in low maintenance areas. Efficient seed production, good seedling vigour and ease of establishment are critical factors for successful domestication (Harlan 1960) and investigations into seed production are a vital part of the commercialisation process.

# **METHODS**

Three accessions from the UNE Microlaena Selection Program were used. Seed was harvested by hand on a weekly basis from five selected plants of each accession for the entire 1992-93 growing season. The accessions chosen were a forage type - accession 41, a turf type - accession 25 and a low maintenance type - accession 17. After the spikelets were removed from the culm, the inflorescences were collected from each plant and counted. At approximately monthly intervals, the number of spikelets produced per inflorescence was recorded. In addition, spikelet and caryopses weights of each plant of the three accessions were recorded over the season. A germination test was carried out on seed harvested in January 1993 and from a later collection in March 1993.

## **RESULTS**

The total cumulative seed yields of the three accessions were not significantly different, and were in the range 1.7-2.2 t/ha. However, variation in the general pattern of seed production was observed among accessions. Inflorescence emergence of accessions 17 and 25 was first observed in mid October 1992 while accession 41 was 4 weeks later. The rate of seed production of accession 25 peaked in early February 1993, accession 17 remained consistently higher through until mid March and the rate of seed production of accession 41 was variable throughout the season. All three accessions continued to produce seed until the end of May 1993.

Accession 17 produced the greatest number of inflorescences per plant and recorded the highest total seed yield of the three accessions, but had the lowest caryopsis weight. The weight of individual spikelets of accession 41 were much higher and although this accession produced more spikelets per inflorescence, fewer inflorescences per plant were produced. The caryopsis weight of accession 25 was comparable to that of accession 41 although individual spikelet weight was lower.

Seed collected earlier in the season germinated more rapidly than later maturing seed. The presence of ancillary structures (sterile lemmas) inhibited germination of all accessions from both collections

although the effect was greater on the seed collected later in the season. The germination of accession 41 was most severely inhibited by the presence of the ancillary structures.

# **DISCUSSION**

The capacity for seed production of microlaena compares very favourably with that of introduced perennial grass species and far exceeds documented yields of other native grass species. While the final seed yield of each accession was similar, the pattern of production and the components of seed yield among accessions varied significantly during the season. Among accessions, production of reproductive tillers was the most important component determining ultimate yield.

The slower germination of spikelets collected later in the season may be explained by environmental conditions experienced by the parent plant during the period of seed maturation (Fenner 1985). With decreasing temperatures, the slower rate of development of the spikelets may affect the degree of dormancy exhibited. The inhibition of germination due to the presence of the ancillary structures may be a function of the time taken for the radicle to emerge from these structures and mechanical restriction may be involved in the reduced germination of 41 compared with 17 and 25.

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## TAGASASTE; A POSSIBLE FODDER SHRUB FOR THE RANGELANDS

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# **ABSTRACT**

Tagasaste growing in deep sands receiving a rainfall of >350mm is capable of producing 4.5t DM/ha/yr.

18 month old cattle set stocked at 1 beast/ha had an average growth rate of  $0.9 \, \text{kg/hd/day}$ . Edible leaf and stem have a crude protein content of ca. 15%, and digestibility of ca. 70% at production levels of  $4.5t \, \text{DM/ha/yr}$ . Roots are found evenly distributed throughout the soil to depths of 6.4m.

It is demonstrated how tagasaste can play an important role in filling the autumn feed gap in Mediterranean climates, as well as providing a fodder which it is possible to set stock. It also provides soil stabilisation and reduces erosion on poorly productive sands.

#### INTRODUCTION

In the search for fodder shrubs suitable for Australian conditions, tagasaste (*Chamaecytisus palmensis*) has emerged as one of the commercial successes. Tagasaste or 'tree lucerne' is native to the Canary Islands and is a small, evergreen deep rooted leguminous shrub which produces palatable and nutritious leaf and stem material.

#### Growth

Tagasaste is very adaptable in terms of soil types in which it will grow. However, current knowledge suggests that it performs best on well drained deep sands receiving annual rainfall of 350mm or greater. It is the ability of tagasaste to 'transform' otherwise poorly productive deep sands into viable grazing land which makes it desirable as a fodder shrub. Tagasaste grown in hedgerows 5-8m apart at tree densities of 1000/ha or greater is capable of producing from 1.5 - 4.0 tonnes DM/ha/year on these infertile deep sands. This compares favourably to the 1.0 - 2.0 tonnes of DM/ha/year of pasture which could otherwise be expected. In Western Australia approximately 15,000 hectares of deep sands have been established to tagasaste since 1987 (Oldham, 1993).

# Fertiliser Response

Tagasaste is extremely efficient at extracting phosphorus from soil. In soils with an adequate fertiliser history very little response is obtained in terms of DM/ha/yr. However on soils with no previous fertiliser history and regarded as deficient in P, large responses in production can be obtained (Wiley, 1993). It has been suggested by Negus (1991) that the application of phosphorus, copper and zinc where these nutrients are lacking improves markedly the feed value and palatability of the resulting growth. A study of fine roots by Engelke (1992) showed that fine roots less than 2mm in diameter are evenly distributed throughout the soil profile to a depth of 6.4m, suggesting that tagasaste is able to utilise nutrients which have leached below the root zone of shallow rooted annuals.

# Value as Stock Fodder

From recent work it appears that the production potential of tagasaste is increased by grazing with cattle using a set stocking regime. By set stocking, regrowth is maintained at less than 5cm and the resulting new leaf can contain from 10 - 30% protein and be up to 80% digestible. This compares favourably to grazing tagasaste as a summer/autumn feed. Under these conditions, where tagasaste is grazed for a period of 3-4 months then allowed to recover for the remainder of the year, cattle are only able to maintain condition or in some circumstances gain liveweight slowly (Oldham et al. 1991). The protein content of the older leaf and stem is about 14% and digestibility falls to approximately 70%. It is possible that levels of some nutrients in the foliage may be less than what is recommended for grazing animals. In this situation supplements would be employed to correct any nutrient shortfalls.

In July 1991, Oldham (1993) placed heifers weighing 305kg on tagasaste at 1 beast/ha. Regrowth was maintained at a length less than 5cm creating an appearance similar to that of 'broccoli'. The heifers gained around 120 kg in the first 180 days. They stabilised at about 490 kg by November 1992 with a calf at foot (Fig 1). The calves which were dropped over May, June and July 1992 maintained a steady growth rate of approximately 1 kg/hd/day until weaning on the 9th of March 1992 where they averaged 300kg liveweight.

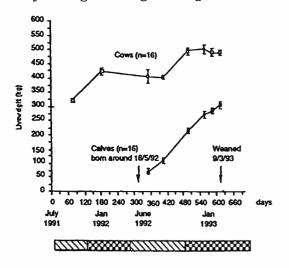


Figure 1. The gains in liveweight made by heifers stocked at 1 beast/ha, then liveweight gains made by the cow-calf unit/ha.

Tagasaste with a green Inter-row
Tagasaste with a dry Inter-row

### **Additional Benefits**

As well as providing usable fodder, tagasaste also has a number of other benefits. These include the stabilisation of deep sands which are often prone to wind and water erosion, providing effective shelter for stock during calving or inclement weather and reducing the problems associated with recharging water tables. Current research on deep sands at New Norcia (WA) suggests that tagasaste is capable of diminishing elevated water tables by 0.4-0.5m annually, compared to annual pastures where the water table is rising by 0.4-0.5m annually (R. Speed, *pers comm.*). As a consequence of the declining water table, catchment salinity levels are also declining.

## **Future Research**

Research into tagasaste will move towards identifying the biochemistry of the plant and how it interacts with grazing animals. One possible method of increasing the feed value is to introduce bacterial inoculants to the rumen. *S. tac* is the name given to the bacteria of interest. This bacteria is resistant to the toxic effects of phenolic compounds present in tagasaste which may make it possible for the grazing animal to utilise tagasaste more efficiently.

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### SHEEP ACT THE GOAT FOR MULGA

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#### **ABSTRACT**

A small volume of feral goat rumen fluid (FGRF) was placed in the rumen of sheep consuming a mulga diet. Rumen bacteria capable of clearing tannin-protein complexes in laboratory culture are apparently unique in feral goats and may benefit sheep by reducing the dietary protein sparing effects of mulga leaf tannins. Sheep inoculated with FGRF ate significantly more mulga, retained significantly more nitrogen (N) and exhibited improved live weight (LW) status and N digestibility. These results suggest that feral goats have a digestive adaptation that is readily transferable to sheep, improving N metabolism. Development and application of this adaptation for sheep may augment or replace traditional supplementation regimes for mulga feeding.

# **INTRODUCTION**

Mulga (*Acacia aneura*) has been relied upon as a drought ration in western Queensland for more than a century. However high levels of tannins, protein binding chemicals present in mulga leaves (Gartner and Hurwood 1979), severely limit animal production. Methods have been sought to minimise their effects on protein digestion. Chemical inactivation is successful (Pritchard *et al.* 1992) but it is neither cost effective nor environmentally desirable in grazing enterprises.

Brooker *et al.* (1994) isolated unique tannin-resistant bacteria from the rumen of feral goats consuming mulga. These bacteria do not appear to be a natural component of the rumen microbes of sheep. Consequently, there is a potential that transfer of such microorganisms to the rumen of sheep may improve mulga protein digestion. This experiment evaluated the effect of a FGRF inoculum on N metabolism in sheep consuming a mulga diet.

# **METHODS**

Ten five-year old merino wethers were placed in individual metabolism cages and fed a diet of stripped mulga leaf *ad lib* at 0800 hours each day. This regime was continued for 32 days to allow the natural rumen microbial population to adapt and stabilise. During the last ten days of this period a metabolism study was conducted to establish basal N metabolism. On the 33rd day the sheep were stratified on dry matter intake (DMI) and randomly allocated to two equal groups. Two feral goats were then slaughtered and the rumen contents strained through a fine mesh screen. A 160 ml sample of rumen fluid was administered orally to each sheep in group 1 within ten minutes of straining the fluid. Group 2 were not inoculated. A second ten day metabolism study was conducted 21 days after inoculation. LW was monitored each week throughout the experiment.

#### **RESULTS**

Prior to inoculation the sheep had similar (general mean +/- standard deviation) DMI (487+/-104.1 g/day), N balances (-0.30+/-0.694 g/day), N digestibilities (374+/-52.4 g/kg) and LW losses (77+/-26.7 g/day). Both DMI and N balance were significantly higher (P<0.05) after inoculation with FGRF (Table 1). LW and N digestibility were improved by inoculation but not significantly.

# **DISCUSSION**

Tannins affect microorganisms in a number of ways, reducing their ability to function and survive. We believe that particular feral goat rumen bacteria, acting in consortia, have evolved mechanisms to cope with high levels of dietary tannins. These synergistic adaptations may improve the survival of the bacteria, promoting an increase in efficiency of rumen digestion, fermentation rate and dietary intake. The results of this experiment suggest that such improvements in digestion are experienced by sheep inoculated with FGRF; the improvement in N balance resulting from a combination of increased DMI and N digestibility.

Table 1. DMI, N balance and digestibility, and LW change of sheep with or without a FGRF inoculum.

	Uninoculated	Inoculated	Standard deviation	Significance
DMI (g/day)	395a	541b	102.6	P<0.05
N balance (g/day)	-1.11a	0.08b	0.901	P<0.05
N digestibility (g/kg)	325	390	64.4	ns
LW change (g/day)	-108	-56	43.7	ns

At present, mineral supplements containing N, phosphorus and sulphur are fed to sheep consuming a mulga diet to minimise the nutrient deficiencies caused by the protein binding actions of tannins. These supplements significantly improve production (Niven and McMeniman 1983). The results obtained in this experiment indicate that a small volume inoculum of FGRF may benefit sheep similarly but at a reduced cost.

Future research will expand on these findings and in particular, examine the potential for natural transmission of the microbes between animals. This will help determine the practicality of inoculating with FGRF or identify a need to produce commercial quantities of an artificial inoculum.

# **ACKNOWLEDGMENTS**

We would like to thank the Australian Wool Research and Promotion Organisation for supporting the mulga research program. Thanks also to Mr. Des Mallet and Mr. Ken Rundle for technical assistance.

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# SELF MUSTERING OF SHEEP - MUSTER IN YOUR SLEEP

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#### **ABSTRACT**

For much of rangeland Australia conventional mustering is expensive, inefficient, requires skilled labour and is stressful for the sheep and the operator. Industry has responded to these challenges with the use of improved technologies such as aerial spotting, radios and motorbikes. However, mustering still remains a problem.

Self mustering by trapping on water is another tool available to the sheep industry. Self mustering means clean musters and clean country, a clean product from improved husbandry and clear profits.

This paper summarises work supported by woolgrowers through the Australian Wool Research and Promotion Organisation and discusses the free book 'Sheep Self Mustering - muster in your sleep'. The book includes do-it-yourself plans, materials lists and construction details for four trap gate designs.

### **DISCUSSION**

Self mustering by trapping on water is smarter mustering. It is so easy that the sheep can almost be mustered in your sleep, and now there is a free, concise and practical book to show you how. The 'Sheep Self Mustering' book is very easy to read and contains all that is needed to get started and to do the job properly.

The 'Sheep Self Mustering' book introduces the reader to self mustering of sheep. It discusses four trap gate designs for which there are comprehensive, easy-to-use plans, construction details and a materials list. The plans include a front, side and plan view as well as more detailed information about specific components where necessary. The book also looks at the training required and includes the positive comments of graziers already using self mustering of sheep.

Each of the four designs (Bettini, Charleville, Spring Hill and Cattle/Sheep) works well. There are two designs, the Cattle/Sheep and Spring Hill, suitable for paddocks in which sheep and cattle run together. All can be built in the average property workshop by anyone with some welding skills.

Self mustering is a proven alternative to conventional mustering. Whilst some capital outlay is required in fencing waters and constructing trap gates, this is more than compensated for through savings in time, labour costs and improved animal husbandry. Better husbandry, including sheep lice control, is possible because of the clean musters that can be achieved. By starting with the most difficult-to-muster paddock, self mustering will be given a proper work out, and the best possible return gained for those hard-to-earn dollars.

The original title of this paper was 'Self Mustering of Sheep (cattle, goats and other beasties)'. This title emphasises the versatility of well planned and constructed facilities.

Comments made by two of the grazier co-operators sum up the benefits of self mustering:

Mr Michael Flynn, 'Valeravale' Augathella: 'We have had excellent results. We can clean muster any paddock within two days given suitable weather. Self mustering is a very low stress method of mustering.'

Mr Alan McDonald, 'Shelbourne' Charleville. 'Self mustering works for me and, if it does rain sometime, I plan to equip every watering point I can with traps.'

The 'Sheep Self Mustering' book is available free by contacting any Department of Primary Industries office in western Queensland or from Noel O'Dempsey (076) 544200.

Self mustering means clean musters and clean country, a clean product from improved husbandry and clear profits.

#### **ACKNOWLEDGEMENTS**

Many people have made this work possible. There are too many people to name them all individually, so we hope that a collective 'Thank You' will suffice. However it must be mentioned that the 'Self Mustering for Sheep' project enjoyed the support of woolgrowers through the Australian Wool Research and Promotion Organisation (formerly Wool Research and Development Corporation).

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# THE PRODUCTIVITY OF MONO AND MIXED-GRAZED GOATS AND SHEEP UNDER SHELTERED AND NON-SHELTERED ENVIRONMENTS

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#### **ABSTRACT**

This study examined the productivity of goats and sheep grazing together and separately in sheltered and non-sheltered environments from September to December 1990. In the sheltered paddocks, the average liveweight gain of mixed-grazed goats and sheep was consistently higher (102% and 55%) than when grazed separately. Without shelter, the mixed-grazed goats had significantly higher weight gain (P<0.05) during the month of December as compared to mono-grazed goats (25 vs 9 g/hd/day). On the other hand, mixed-grazed sheep had significantly higher weight gain (P<0.05) than mono-grazed sheep during the month of September (131 vs 57 g/hd/day), November (75 vs 22 g/hd/day), December (56 vs 26 g/hd/day). The sheep grazed alone had significantly higher liveweight gains in the sheltered paddocks than in the non-sheltered paddocks (45 vs 22 g/hd/day).

#### INTRODUCTION

Information on the use of shelter for small ruminant animal production is limited. There has been no research done on the use of shelter for mixed grazing of goats and sheep in a temperate environment. Shelter is important to protect animals from any adverse effects of climate. For example, the lack of shade in hot conditions impaired the productive performance of sheep (Stephenson *et al.* 1984, Squires 1981).

#### METHODS AND MATERIALS

This experiment consisted of three grazing groups of animals (mono-grazed goats, mono-grazed sheep and mixed grazed goats and sheep) and two systems of exposure in spring (animals with shelter and without shelter). The design was  $2 \times 3$  factorial in a randomised block with 3 replications per treatment. The animals used were Angora goats and Merino wethers (2-2.5 yrs old) from the University Research station at Wellington, NSW. They were grazed on an irrigated phalaris-white clover pasture.

## RESULTS AND DISCUSSION

In the sheltered paddocks, the average liveweight gain of mixed-grazed goats and sheep was heavier than the mono-grazed goats and sheep (Table 1). The highest liveweight gain was observed in mixed-grazed goats in November (59 g/hd/day) and sheep in September (125 g/hd/day). Without shelter, the mixed-grazed goats had significantly higher weight gains (P<0.05) than the mono-grazed goats during the month of December (25 vs 9 g/hd/day). Similarly, the mixed-grazed sheep had more gain than the mono-grazed sheep (P<0.05) during the months of September (131 vs 57 g/hd), November (75 vs 22 g/hd), and December (56 vs 26 g/hd/day). The animals with access to shelter performed better than the animals without shelter (Table 1).

The peak of sheltering of both species groups was from 10 a.m. to 3 pm. This could be because the animals could not tolerate the effect of the temperature during this period and because each species group has its optimum temperature requirement below that recorded. Overall, the sheep groups spent more time resting in the shelter than the goat group. Perhaps animals which did not use the shelter were becoming better adapted to the environment.

# CONCLUSION

The average liveweight gain of goats in sheltered paddocks increased by 107% and sheep by 55%, while mixed grazing improved the average liveweight gain of goats by 223% and sheep by 149%. This study demonstrates that complementary grazing and shelter are important factors to consider in grazing management.

Table 1. Daily liveweight gain of goats and sheep grazing alone or together under sheltered and non-sheltered environments (gram/hd).

	With Shelter		Without Shelter	
	(g)	S.E.:	(g)	S.E.
SEPTEMBER 90 (22 days)				
goats alone	34de	2	33e	4
mixed	56d	8	42de	11
sheep alone	80b	7	57cd	4
mixed	125a	9	131a	6
OCTOBER 90 (22 days)				
goats alone	19bc	2	17cd	5
mixed	41a	8	12d	8
sheep alone	15cd	3	15cd	2
mixed	35ab	5	24db	9
NOVEMBER 90 (21 days)				
goats alone	24de	3	17e	2
mixed	59bc	5	19e	9
sheep alone	45c	3	<b>22</b> e	7
mixed	91a	6	75ab	6
DECEMBER 90 (21 days)				
goats alone	-5ce	4	-9e	8
mixed	17bce	13	25bc	6
sheep alone	34ab	3	26bc	4
mixed	83a	13	56ab	14

<sup>• =</sup> Standard error of the mean.

Any two means having a common letter are not significantly different at the 5% level of significance.

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# FACTORS INFLUENCING THE BEHAVIOUR OF MONO AND MIXED-GRAZED FERAL DOES AND MERINO EWES UNDER LSR AND HSR

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#### INTRODUCTION

Information on aspects of animal behaviour is scarce and varies. Understanding the interaction between animals' activity and their environment is an important consideration in maintaining a stable and efficient grazing production enterprise. This study was designed to investigate the factors that affect the activity of mono and mixed-grazing feral does and Merino ewes and its implication for management and productivity.

#### MATERIALS AND METHODS

This experiment consisted of three grazing groups: mono-grazed goats, mono-grazed sheep, mixed-grazed goats and sheep; two stocking rates, low (LSR) and high (HSR); and three replicates. The design was a  $2 \times 3 \times 3$  factorial in randomised split block design (RBD). Observations were taken from 6 a.m. to 12:00 noon and 1-6 p.m. Animal behaviour was observed at 15-minute intervals with a 5 min. break in between to give time for the observers to make other observations.

# RESULTS AND DISCUSSION

Animals spend more time grazing at HSR (58%) than at LSR (48%). AT HSR, pasture on offer was reduced to a certain level because the animals exerted more effort and time in satisfying their nutritional needs. At high feed availability (2.5 to 3.2 tons/ha) mixed-grazed goats and sheep spent more time grazing (249 and 279 min.) compared with each species grazing separately (181 to 242 min.). This could be due to a complementary effect which was reflected in their better performance.

Ruminating time increased from spring to summer by 22% and decreased from autumn to winter by 44%. The ruminating time was strongly correlated with the quality of the pasture (r=1.0) and temperature (r=0.99). The time spent ruminating appeared to be lower in the sheep than in goats. This observation is partly explained by their food preference as goats browsed mostly the upper portion of the vegetation which needed more chewing, while the sheep grazed the pasture that was close to the ground which needed less chewing. On hot days, sheep spent more time standing than lying. The reverse was true for goats. In summer and autumn under very hot shadeless conditions, the goats dig holes, while the sheep gather into small groups and shade their heads under each other rather than lying down.

The diurnal pattern of mixed-grazed goats and sheep was less variable throughout the experimental period, while with mono-grazed goats and sheep, their grazing pattern differed. During winter, autumn and spring, there was no definite time when the animals started and stopped grazing. The major grazing periods began near dawn and again near sunset (Fig. 1). The presence of trees in the paddocks could be one reason why the animals grazed almost continuously during daylight. The activity of grazing animals such as idling, ruminating and standing was strongly influenced by temperature (r=0.96). The behaviour of goats was also related to the height (r=0.96) and density (r=0.99) of the pasture.

Goats' behaviour was sensitive to height of the pasture. Sheep liveweight gain did not vary with pasture height. With the sheep however, performance was better when the pasture height was low (4 cm). The liveweight gain of goats was shown to be positively associated with pasture height (r=0.98). The performance of goats was strongly related to pasture density (r=0.99). The higher the density of the pasture, the higher the liveweight gain of the goats (r=0.99), while sheep gain was unrelated to pasture density.

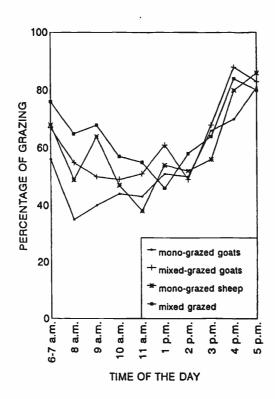


Figure 1. Average diurnal pattern of mono and mixed grazed goats and sheep during summer, autumn, winter and summer 1992.

#### CONCLUSION

Animals at HSR spent more time grazing than at LSR. The provision of shelter (e.g. trees) is important to grazing management. Mixed grazed goats and sheep spent more time grazing compared to when they were grazed separately. Mixed grazed groups had superior liveweight gain compared with monograzed groups. The quantity and quality of the pasture influenced rumination. Pasture height and density, and ambient temperature influenced the diurnal behaviour of goats and sheep. Pasture density and height determined the grazing behaviour and performance of goats and sheep.

# RESULTS FROM SWIFTSYND TRIALS ON IMPROVED AND NATIVE PASTURES AT DOUGLAS DALY, N.T.

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# INTRODUCTION

The Australian Semi-Arid Tropics (SAT) is predominantly used for cattle production, with limited cropping. The region experiences distinct wet and dry seasons annually, with generally highly erosive rainstorms having potential to cause significant damage to poorly managed lands. Land management practices and strategies therefore, can prove crucial to the sustainable productivity of the land.

To facilitate sustainable development and management of land resources, the dynamics and interactions of soil, plant, water, and climate need to be understood. Computer simulation models provide a tool to enable this. The Land Management Strategies for the Semi-Arid Tropics project in collaboration with Agricultural Production Systems Research Unit is developing such a computer simulation model called APSIM (Dilshad, 1993). One of the modules of the APSIM model will be a pasture productivity model called GRASP (McKeon et al., 1993) developed by Queensland Department of Primary Industries. The parameters required to run GRASP are obtained from a pasture growth trial called SWIFTSYND. The purpose of this poster is to briefly present the results gained from SWIFTSYND studies conducted at Douglas Daly in the Northern Territory.

# DESCRIPTION OF EXPERIMENT

**Site:** The study area was situated on Kandosol soils (Isbell, 1993) at the Douglas Daly Research Farm (DDRF), 250 km south of Darwin. The experimental sites were located on 4 paddocks ranging in size from 4.1 to 7.8 ha, and on slopes of less than 2%. Historic mean annual rainfall for DDRF is 1200mm. Three paddocks were sown with *Urachloa mosambicensis* (Sabi grass), and one was left as native bush with *Heteropogon contortus* (twisted spear grass) dominant.

**Sample Area:** Each paddock had two  $18m \times 13.5m$  sampling areas inside  $20m \times 20m$  fenced areas. Each sampling area had nine  $5m \times 3.5m$  blocks pegged out, with walkways in between blocks. In each block, six  $1m \times 1m$  quadrats could be placed without overlapping. There were three neutron probe access tubes in each fenced area.

**Data Collected:** A set of 9 quadrat readings was taken of pasture growth inside each sampling area at specific sampling dates. Data collected included visual estimates of ground cover, soil moisture, dry matter yield and chemical analysis of vegetative matter. Rain gauges were located around the study areas. Other relevant climate data were recorded at a station 2km west of the experimental sites.

**Cover:** A 1m x 1m quadrat was used to visually measure percent ground cover (attached, weed, litter), and bare ground. Attached cover is any plant material that is still attached to a growing plant and not classified as a weed. Litter is any unattached plant material on the ground.

**Yield:** A set of shears was used to harvest plant material (attached, weed) as close as possible to the ground inside the quadrat, whilst litter was collected by hand. Samples were oven dried at 78°C for 48 hours, after which they were weighed.

**Soil moisture:** Immediately after harvesting a quadrat, gravimetric soil moisture readings were taken within the quadrat for 0-10, 10-20, and 20-30cm depths. A neutron probe was used to measure soil moisture from 40cm to 180cm depth at every 20cm interval.

**Chemical analysis:** After each yield was recorded, the sample was ground down as fine as possible to enable macro and micronutrient levels to be determined.

**Sampling Times:** The fenced areas with improved pastures were mown at the beginning of the trial (Sep. 92) and lightly raked to obtain identical ground cover conditions; native pasture was burnt.

Sampling times were determined by the pasture reaching critical stages in its growth cycle. Initial samples were collected on completion of the site preparation. The second set of samples (Nov. 92) targeted the first flush of growth for the season. The aim of the third set of samples (Dec. 92) was to obtain data at the flowering and seeding stage. The fourth sampling (Mar. 93) was done towards the end of the growing season when the plants were at their highest yield levels. The final set of samples (Aug. 93) was collected at the end of the non-growing season.

#### RESULTS AND DISCUSSION

**Cover:** On improved pasture, attached cover increased from 22% in Oct. 92 (47% total plant cover - TPC) to 92% in Mar. 93 (93% TPC). The corresponding figures for native pasture were, 5% (26% TPC) and to 36% (78% TPC).

#### Yield:

Attached: From a base reading near zero (Oct. 92), improved pasture yields increased to 1.2 t/ha (Nov. 92), whilst native pasture increased to 0.13 t/ha. From Nov. 92 to Dec. 92, improved pasture increased to 2.38 t/ha, and native pasture to 0.25 t/ha. Dec. 92 to Mar. 93 experienced an increase in yield to 4.37 t/ha and 1.48 t/ha for improved and native pasture respectively. Over the non-growing season improved pasture yields dropped to 3.83 t/ha. No readings were taken for the native pasture due to a bushfire in early Aug. 93.

Litter: Litter on the improved pasture sites remained between 0.5 and 1.0 t/ha throughout the growing season. Litter on the native pasture ranged from 1.13 t/ha to 1.8 t/ha. In Aug. 93, litter on improved pasture ranged between 2.0 and 3.2 t/ha. No readings were taken for the native pasture due to the bushfire.

**Water use:** Volumetric moisture content (vmc) for improved pasture did not change considerably during the sampling period for depths of 60cm to 180cm; vmc varied between 22% and 28%. The top 40cm showed marked variations primarily due to climate conditions. Native pasture displayed similar trends.

**Chemical analysis:** N levels for attached cover at all sites were similar for the trial; Oct. 92 started with levels of 0.2 to 0.5% (1% = 1000ppm) and increased dramatically by Nov. 92 to levels of 1.0 to 1.7%. This was followed by a drop in Dec. 92 to 0.7% and stabilised at 0.6% for the rest of the trial. N levels for litter ranged from 0.5 to 0.9% for the entire trial. Native pasture displayed similar trends.

**P** levels on improved pasture remained steady at 0.25% during the first part of the trial but increased to approximately 1.75% in Mar. 93. Litter experienced a similar pattern with P levels at 0.2% up to Dec. 92, and increasing to 1.25% by Mar. 93. Native pasture displayed similar trends.

Improved pasture **K** levels for attached cover followed trends similar to that for N. For improved pasture, K increased from 1.0% in Sep. 92 to 5.0% in Nov. 92. K levels of 3.5% were recorded in Dec. 92, which dropped to 0.25% in Mar. 93. A similar trend, but of a lower degree, was observed for native pasture.

#### CONCLUSION

The SWIFTSYND trial has identified patterns of pasture growth, chemical movement, and water use over a complete growth cycle for native and improved pasture in the Douglas Daly region of the Northern Territory. This high quality data can now be used to develop parameter files for the GRASP model.

# **ACKNOWLEDGEMENTS**

This study was part of the LAMSAT project and was funded by Land and Water Resources Research and Development Corporation. Many thanks to Peter Bagley and staff at Douglas Daly Research Farm, and also to Mark Silburn, QDPI.

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# IMPROVED PREDICTION OF SOIL MOISTURE AND RUNOFF IN PASTURE MODELS

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#### ABSTRACT AND CONCLUSIONS

Soil moisture and runoff predictions using the GRASP pasture model were tested for a range of pasture conditions in Central Queensland. Soil water and grass growth parameters were measured independently. Good predictions of soil moisture were obtained using the existing GRASP runoff model, without calibration. Runoff was predicted well for plots with little cover, but not for plots with high cover. When the USDA 'curve number' runoff model from PERFECT was included in GRASP and calibrated for each condition, good predictions of both soil moisture and runoff were obtained. Fitted runoff parameters were highly related to projected cover. A runoff-cover equation was derived for inclusion in pasture models, providing a feedback between land use and water balance.

# INTRODUCTION AND METHODS

Runoff is a large water balance component for pasture under poor land management (Silburn *et al.* 1992). Pasture models must include land use effects on the water balance if they are to be used to study land degradation and drought. In this study (Yee Yet 1994), soil moisture and runoff predicted using the GRASP pasture model (McKeon *et al.* 1990) were compared with measured data for 5 years (Silburn *et al.* 1992), for four rangeland conditions in Central Queensland:- a) good grass cover; b) poor grass/high tree density; c) bare scald; and d) poor grass cover/heavily grazed. Soil water parameters were measured on artificially wet soil profiles. Grass growth parameters were derived from Willcocks and Filet (1993).

# **RESULTS AND DISCUSSION**

Good predictions of soil moisture were obtained using the existing GRASP runoff model, without calibration. Runoff was predicted well for plots with little cover, but not for plots with high cover. Predictions were improved for the high tree density plot by including a tree litter cover component. When the USDA 'curve number' runoff model from PERFECT (Littleboy *et al.* 1992) was included in GRASP and calibrated for each rangeland condition, very good predictions were obtained for both soil moisture (Fig. 1) and runoff (Fig. 2). Only the runoff parameter was adjusted during calibration.

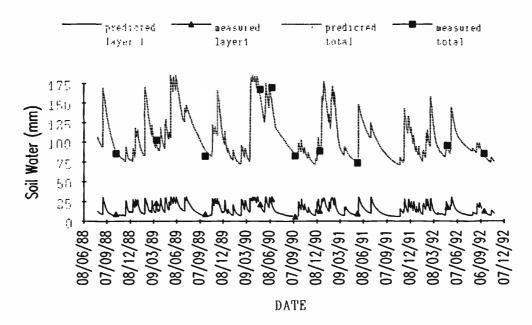
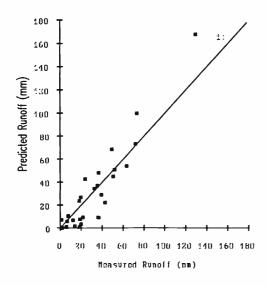


Figure 1. Measured and predicted soil water, total soil (0-50cm) and surface (0-10cm), for good grass cover.

The fitted runoff parameter (CN2) was highly related to projected cover (standing grass plus grass and tree litter) across all conditions, and a runoff-cover equation (Fig. 3) was derived for inclusion in pasture models. In comparison with cultivated cracking clay soils (Fig. 3), the hard setting pasture soil in this study has a much higher runoff potential (high CN2) and is more sensitive to cover (high slope of CN2-cover relationship). When the relationship in Fig. 3 was included in GRASP with the curve number runoff model (so that runoff predictions were influenced by predicted cover), soil moisture, runoff and grass growth were still well predicted. This indicates that estimates of cover in GRASP were good enough to drive the runoff model without introducing errors.



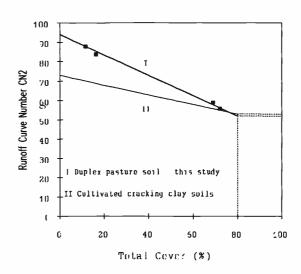


Figure 2. Measured and predicted (GRASP) runoff for bare scald.

Figure 3. Cover effect on USDA curve number (CN2) runoff parameter for pasture soil (this study), compared with cultivated cracking clay.

# **ACKNOWLEDGMENTS**

This study is a contribution to the LAMSAT project and was funded by Land and Water Resources Research and Development Corporation and Queensland Department of Primary Industries.

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#### WATER RELATIONS BETWEEN A MISTLETOE AND TWO OF ITS HOSTS

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#### **ABSTRACT**

Leaf morphology of a mistletoe species, Lysiana exocarpi subsp. exocarpi and its two host species, Heterodendrum oleifolium and Myoporum platycarpum were examined. While stomata dimensions of the mistletoe are larger than those of H. oleifolium and comparable with those of M. platycarpum, stomatal density of the mistletoe was only half as high as those of the two hosts. Stomatal conductance of the three species exhibits similar diurnal patterns, but stomatal conductance of the mistletoe is constantly higher than that of the two host species. It appears that stomatal conductance of the mistletoe and its hosts is primarily determined by stomatal movement, and size and density plays a less significant role.

# INTRODUCTION

Mistletoes usually have much higher water conductance, hence higher transpiration rate than their hosts. This high transpiration rate of mistletoes has been suggested as a physiological necessity in order for them to maintain a more negative water potential, to obtain sufficient mineral nutrient, and more recently to enable the parasite to obtain carbon from the host. There is little information on mechanisms controlling the transpiration process of mistletoes and their hosts. This study examined leaf morphology and diurnal variation in stomatal conductance of *Lysiana exocarpi* (Behr) Tieghem subsp. *exocarpi* and two of its host species, *Heterodendrum oleifolium* Desf., and *Myoporum platycarpum* R. Br. Field work was conducted at Brookfield Conservation Park (BCP), which is 150 km north-east of Adelaide.

# MATERIALS AND METHODS

Leaf samples were collected from BCP in January 1989. Impressions of the abaxial and adaxial sides of each leaf were taken with clear nail polish and mounted on microscope slides. These replicas were examined under the microscope. The length of the stomatal complex was measured at 400x magnification with a micrometer. Stomatal frequency was determined by counting the number of stomata in fields with areas of 0.65 to 1.30 mm². Leaf surface characteristics were examined under a scanning electron microscope.

Diurnal stomatal conductances of *L. exocarpi* and the two host species were measured with porometer during January 1988 to February 1989 on an average of two days per month, to a total of 21 days. For each species, 4-6 leaves were sampled from two adjacent plants. All leaves sampled were from approximately the same location with respect to exposure and stage of development. All selected individuals were located within an  $100 \times 100 \, \text{m}^2$  study site. Measurements were carried out every two hours from 8:00 to 18:00 (CST).

# **RESULTS**

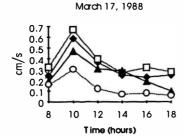
All three species examined have flat leaves. Scanning electron micrographs revealed that *H. oleifolium* and *L. exocarpi* form sunken stomata, but no such structure was observed for *M. platycarpum*. The epidermis of *M. platycarpum* is covered by a layer of external deposits, possibly wax, and some of the stomatal pores appear to be blocked by this deposition. Hairs are present on *H. oleifolium* but absent from *M. platycarpum* and *L. exocarpi*. There were significant variations in stomatal size among the three species (ANOVA, *P*<0.001) (Table 1). *H. oleifolium* had the smallest stomata, being half the size of those of *L. exocarpi* and *M. platycarpum*. The average stomatal density of the two host species was approximately twice as high as those of the mistletoe.

There was marked among-species variation in the magnitude of stomatal conductance (Fig. 1). The stomatal conductance of *L. exocarpi* was consistently higher than that of its host species. Maximum diurnal differences usually occurred when stomatal conductances of the host and the parasite were at maxima. Of the two host species, leaf conductance of *H. oleifolium* was consistently higher than

that of *M. platycarpum*. Leaf conductance of *L. exocarpi* growing on *H. oleifolium* was also higher than that of those on *M. platycarpum*.

Table 1. Stomatal size and density (+/- std err) of *L. exocarpi* and two of its hosts, *H. oleifolium* and *M. platycarpum*.

Species	Stomatal size (um)		Stomatal	2)	
	Adaxial	Adaxial	Adaxial	Adaxial	Average
H. oleifolium L. exocarpi M. platycarpum	18.0+/-0.26 36.5+/-0.29 30.0+/-0.28	15.1+/-0.19 36.4+/-0.36 33.9+/-0.39	62.8+/-4.67 49.0+/-2.43 107.3+/-6.10	183.2+/-8.32 60.5+/-2.87 100.6+/-3.77	123.0 55.5 103.5



Water conductance

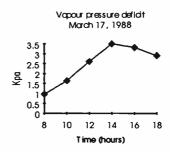


Fig. 1. Diurnal water vapour conductance of H. oleifolium (HO) ( $\spadesuit$ ), L. exocarpi growing on H. oleifolium (LH) ( $\square$ ), M. platycarpum (MP) (O), and L. exocarpi growing on M. platycarpum (LM) ( $\spadesuit$ ) and diurnal vapour pressure deficit on March 17, 1988.

#### **DISCUSSION**

Stomatal density and stomatal size are two of the major plant components which influence gas exchange (Kramer 1969). High density and large size of the stomata reduce their resistance to vapour diffusion and are generally interpreted as characteristics of plants growing under optimal water conditions. On the other hand, plants growing in a dry environment often have fewer and smaller stomata, which are associated with reduced stomatal conductance. In the present investigation, considerable variation existed in both stomatal density and stomatal size and leaf stomatal conductance between mistletoe and its two hosts and between the two host species. However, the higher stomatal conductance measured in the present study appeared not to be correlated with increased stomatal size and density. Stomata of *L. exocarpi* are larger than those of *H. oleifolium* and are comparable with those of *M. platycarpum*, while the density of its stomatal length is only about half that of its two hosts. Yet the conductance of this species is usually higher than those of the two hosts.

Substomatal chambers are generally interpreted as a water conserving structure of plants growing under arid and semi-arid conditions (Kramer 1969). Such structures are observed in the mistletoe species, *L. exocarpi* and one of its hosts, *H. oleifolium*. The higher stomatal conductances of the mistletoe than that of the two hosts indicated that substomatal chamber plays an insignificant role in the present cases. A fourth component that influences plant gas exchange is the aperture of stomatal opening (Kramer 1969). It is more likely that stomata of *L. exocarpi* are able to open wider than those of the two host species under similar and/or more severe water stress and hence are largely accountable for the constantly higher stomatal conductances recorded for *L. exocarpi* than those for the two host species.

The occlusion of stomatal pores by epicuticular deposits may also play a significant role in influencing stomatal conductance. Leaf surfaces of *M. platycarpum* are rich in external deposits, which block a large proportion of stomata. This condition may contribute to the low stomatal conductance observed for this host. In comparison, there are no external depositions on the leaves of *H. oleifolium* and *L. exocarpi* and maximal stomatal conductance of these two species is generally higher than that of *M. platycarpum*.

#### **ACKNOWLEDGEMENTS**

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# RANGE CONDITION AND TREND (RESEARCH)

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#### INVESTIGATION OF THE RELATIONSHIP BETWEEN COVER AND YIELD

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## **ABSTRACT**

Pasture yield is one of the most important characteristics required for short-term forage availability management. Since clipping is such a time consuming method of yield determination, creating an indirect method of yield estimation was considered. The relationship between foliage cover, canopy cover and plant production was investigated for four different land systems in arid and semi-arid areas of the Western Division of NSW. Results showed that there is a good relationship between both types of cover and yield (P<0.05 and <0.01) and cover could be a good predictor of yield. The relationship was sustainable in different times and seasonal conditions.

#### INTRODUCTION

Plant production measurement is important because production directly influences the grazing capacity of the range for both native and domestic herbivores (Hughes *et al.*, 1987). The clipping and weighing method has been recognised as the most common and best direct method of herbaceous production measurement (Bonham, 1989). However it is costly, time consuming and affects the physiology of plants (Springfield, 1974). Many destructive and non-destructive methods have been devised to estimate plant biomass, but all have some limitations. Since clipping is such a time consuming method of yield determination, researchers have investigated other variables which might be related to herbage weight and production.

The use of cover to predict herbage weight is based on the idea that cover is easier to measure and can be done more accurately. Although much work has been done on the relationship between cover and yield, the sustainability of the relationship and accuracy of any equation obtained in different times has not been adequately tested. Most authors collected only one set of data from a small number of species and limited areas.

### **METHODS**

Data were collected during different seasonal conditions from two different land systems at Nyngan (Canonbar) and Cobar (Manuka) as semi-arid areas and two different land systems at Fowlers Gap (Sandstone and Conservation paddocks) in a more arid area. Canopy cover (CC), foliage cover (FC) and herbage production of individual species were measured within 52 half square metre quadrats at the semi-arid sites. Measurements were made in  $40 \times 3 \text{m}^2$  quadrats at Fowlers Gap along four 300 m parallel transects, which were established by Soil Conservation Service. Regression analysis was carried out between FC and CC as independent variables, and production as the dependent variable for species showing statistically significant correlations for each land system. Probabilities of 95% and 99% were used to determine significance.

#### RESULTS

Seasonal conditions varied from drought in mid 1991 and early 1992 to good conditions in late 1992 and early 1993. The principal vegetation cover and yield was perennial grasses for Manuka and Canonbar and saltbush for Fowlers Gap. The ephemeral species were only a small portion of dry matter during the drought and a considerable portion in the good season at Fowlers Gap. Coefficients of determination ranged from 0.96 for perennial forb CC and its herbage yield at the Conservation site down to 0.10 for total yield and CC at the Canonbar site. Due to greater uniformity of vegetation at Canonbar, the highest correlation coefficients were observed between variables at this site. In semi-arid areas generally both CC and FC had a good relationship with yield and both can be used as predictors of pasture yield. In arid areas, especially Conservation site at Fowlers Gap, there was a higher correlation between CC and yield. However, it was not a good predictor of the yield of non-dominant species (mostly annual forbs) in a drought period. This is because it is impossible to estimate the cover of small and fragmented species within a 3m² quadrat. Lower correlations of FC

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with yield at Fowlers Gap, particularly for forbs, may relate to an unsuitable size of the point frame for this group of species. Although the seasonal conditions varied among drought, severe drought, and a good season, the result showed the sustainability of the relationship between cover and yield in any condition.

#### **DISCUSSION**

Vegetation cover measurement has the potential for estimating rangeland production for species and species groups in the Western Division of NSW. The relationship between cover and yield is stronger for areas with uniform vegetation types. A cover-based estimate of yield has the advantage of indicating botanical composition and condition changes. The method is less subjective than other indirect methods for yield estimation. A knowledge of vegetation indices is also required because of high interest in using satellite images for rangeland monitoring. The relationship between cover and yield was stable in various conditions.

Equations can be adjusted for each land system and rainfall fluctuations should also be taken into account (as suggested by Bartolome and Kosco [1982]). Similar studies are required for different land systems and vegetation types to test their cover-biomass relationship and to produce appropriate regression equations. Following our previous research, FC can be measured either by wheel-point or point frame techniques.

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# A DOUBLE SAMPLING METHOD FOR ESTIMATING FORAGE PRODUCTION FROM COVER MEASUREMENT

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### **ABSTRACT**

A double sampling method for estimating rangeland production by cover measurement in the Western Division of NSW was established. Equations can be calculated for each group of species using 8 or 12 clipped quadrats as direct samples and foliage cover or canopy cover of plants as indirect sampling. The model was tested and no significant differences between actual yield and estimated yield were found.

# INTRODUCTION

Double sampling can be an effective technique in reducing the variance of the mean biomass estimation. One of the major problem in double sampling is determining the number of samples required for both direct and indirect measurement to give the desired precision for maximum economy (Ahmed and Bonham, 1982). Such a study has not been conducted in the Western Division of NSW. The objective of the study was to generate a double sampling procedure which can be used for accurate estimation of rangeland production by cover measurement in different condition in the region.

# **METHODS**

Data were collected during different seasonal conditions from Cobar (Manuka) as a semi-arid area and at Fowlers Gap (Conservation paddocks) in a more arid area. Canopy cover (CC), foliage cover (FC) and herbage production of individual species were measured within 52 half square metre quadrats at the semi-arid site and in  $40 \times 3m^2$  quadrats at Fowlers Gap. The latter measurements were made along four 300m parallel transects which were established by the Soil Conservation Service at each site. Dry matter yield of groups of species and total yield were determined using clipping as a direct sampling method. Relative variance accuracy (RAV) of different numbers of pairs of indirect and direct measurements were calculated to determine the required sample number of the direct method to obtain a desired accuracy. The data gathered from an exclosure at Manuka and 20% of samples unused in the analysis from Conservation site were used to test the model. The formula of  $C = nc_n + n'c_n$  which was used by Uresk *et al.* (1977) and Ahmed and Bonham (1982) was used for determining the total times required for both direct and indirect sampling for each level of paired sampling. They assumed fixed total costs or time required for double sampling then determined the sample size of direct samples was fixed and sample size of direct samples was determined by RVA calculation.

# **RESULTS**

Several levels of paired samples were examined to check the given RVA. The level of accuracy was sharply increased between 4-8 paired samples. However desirable accuracy was obtained with between 8 and 12 paired samples. The level of accuracy was slightly increased from 12 to 20 paired samples and then was about constant for pairs more than 20.

Time consumption of sampling was slightly increased from 4-8 direct samples and then sharply increased from 8 to 40 direct samples. The unit of time shown in the figures is minutes and is for sampling done by two people. The time consumption for estimating yield by CC measurement was less than by FC measurement at the semi-arid site. Due to the bigger sample size at Fowlers Gap, the time needed for the same number of direct and lesser number of indirect samples (40 quadrats) is greater than the time needed at the semi-arid site.

High coefficients of determination were obtained for both the 8 and 12 sample sets for most groups of species. There were no significant differences between r<sup>2</sup> values derived from regression based on

either 8 samples or 12 samples. The results of testing equations at Manuka and Conservation indicated that equations derived from 8 or 12 samples could estimate yield accurately. No significant differences were found between estimated yield by double sampling based on 8 and 12 clipped samples and actual yield measured by clipping (P<0.01). Forage production was more accurately estimated by FC than by CC at the Manuka site.

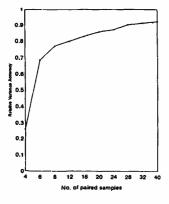


Fig. 1. Relative variance accuracy of different pair levels.

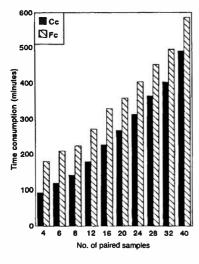


Fig. 2. Double sampling time consumption at Manuka.

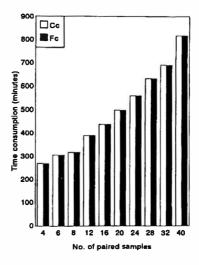


Fig. 3. Double sampling time consumption at Fowlers Gap.

## **DISCUSSION**

Because of the variation in rainfall and grazing pressure that causes different seasonal conditions in the Western Division, the equation calculated for yield estimation based on one set of data which is representative of specific conditions cannot be used constantly without calibration. For minimising personal bias, double sampling for estimating plant dry weight from cover measurements should be used for vegetation communities in which the relationship between cover and yield has been investigated. In this method, cover measurement is used in place of the ocular estimates in the technique described by Pechance and Pickford (1937). The method is fast, accurate and also less subjective than other indirect methods. It is a non destructive method and cover information can also be used for other aspects of range management. The method can be used in any land system and under any conditions where a relationship between cover and yield is possible. Foliage cover or canopy cover can be measured as vegetation cover. The technique was passed as a primary test for one site in the semi-arid and one site in the arid areas of the Western Division.

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# RANGELAND MONITORING WITH AIRBORNE VIDEOGRAPHY

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# **ABSTRACT**

Correction and classification procedures have been developed for airborne video data. The system is now approaching an operational stage where it is capable of rapidly providing information on vegetation cover at a 10-20 cm pixel size.

# INTRODUCTION

Airborne videography can provide a compromise between ground-based methods of data collection and satellite remote sensing in the rangelands. The high spatial resolution of the data (10-20 cm pixel size) makes it possible to resolve and identify small objects (e.g. shrubs, perennial grasses) which is not possible with satellite data. Automated data capture along aircraft flight lines avoids many of the logistic problems of efficiently sampling soil and vegetation in mixed landscapes on the ground. Finally, airborne videography is a relatively low-cost approach to the rapid acquisition of high resolution data, the results are in digital form and are available in close to real time.

## **VIDEO COMPONENTS**

Hardware, flown in a Cessna 210 aircraft, comprises an 80486 PC with an AT&T Vista framegrabber board, a digital multispectral video system of four solid state cameras, two 12V batteries and a DC/AC invertor. The cameras are mounted in an optical frame allowing precise alignment and are fitted with filters in the blue, green, red and infrared parts of the electromagnetic spectrum. Consecutive frames are grabbed and stored in the computer's 64 mB of RAM as frequently as 2.25 seconds producing a nominal 18 cm pixel size with frame overlap at 250 m above ground level and 80 knots ground speed.

# **CORRECTION PROCEDURES**

Several types of correction are needed before video imagery can be used for digital analysis. The first procedure compensates for the effects of aircraft motion. Video data are collected in interlaced mode which means that odd numbered lines are grabbed prior to even lines. With the aircraft moving at approximately 40 m/sec, there is a considerable displacement between adjacent pixels in odd and even lines. This shift produces significant visual distortion in the image and it is further amplified by any aircraft roll in the period between capturing odd and even lines. The other major requirement for correction occurs because the amount of reflected light from a given ground object detected by the camera varies with the viewing angle. This is a function of illumination geometry and lens distortion. Correction procedures have been implemented for both sources of error (Pickup *et al.* in press).

# **CLASSIFICATION**

As a verification tool for satellite data, we require the video imagery to supply rapid estimates of vegetation cover over large areas with a high degree of precision. This information needs to be further partitioned into broad categories such as woody species, herbage and litter.

We have developed a hierarchical procedure for progressively extracting feature information from corrected video imagery (Table 1). The first step involves extracting those vegetation features (e.g. shrubs) which have a broad range of spectral values due to canopy structure. Supervised classification is then used to separate distinct colour variation (e.g. soil type, vegetation phenology) in the remaining image. This often leaves poorly classified areas due to the mixing of components at the pixel scale. Such mixtures typically include soil, litter, shadow and vegetation and where it is possible to resolve these as end-members, mixture modelling is used to estimate the proportions present in each non-classified pixel. In this way, the image is sequentially characterised into meaningful cover components according to the level of spectral variation across pixels.

Table 1. Sequence for extracting ground cover information from video imagery.

Feature Attribute	Pixel Size	Example	Approach
spectrally variable	< feature	shrub canopy	transform to spectrally constant
spectrally unique	<= feature	shadow grass tussocks	supervised classification
spectrally mixed	> feature	soil/grass/litter mixture	mixture model

# **GROUND VERIFICATION**

We have obtained good agreement between estimates of cover obtained from classified video imagery and ground-based estimates for Mitchell grass downs and mixed floodplain sites. Vegetation cover was estimated on the ground in a series of  $5 \times 1$  m windows along a 250 m transect using a set of contiguous 1 m square quadrats. Example results for the shrub layer at the floodplain site are shown in Figure 1.

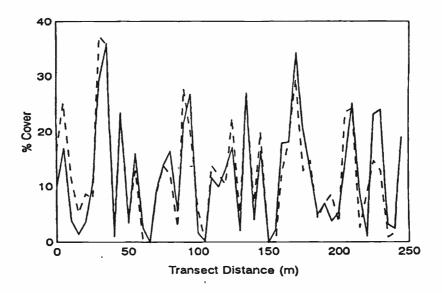


Figure 1. Ground-based estimates of shrub cover (solid line) compared with classified video data (broken line).

Agreement of this nature between classified video data and ground-based sampling of vegetation indicates that airborne videography is approaching the operational stage where it can rapidly provide detailed information about vegetation cover.

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# RAINFALL, SOIL TYPE, GRAZING, AND LAND CONDITION: A NEW LANDSCAPE-SCALE EXPERIMENT.

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#### **ABSTRACT**

In this paper we describe a landscape-scale experiment designed to assess the determinants of land condition in Australia's tropical savannas. Cattle grazing is a major land use on these savannas which occupy 30% of Australia's land mass. We have established study sites on sands, loams and cracking clays at five locations along the rainfall gradient between Darwin and Kalkaringi in the NT. At each site, we have imposed three disturbance regimes which will create a range of land conditions. We will monitor various attributes of the soil and vegetation to assess the transitions in land condition across the range of soil types and rainfall levels. The experiment will run for 5 years.

#### INTRODUCTION

In the north-west of Australia, the land has been relatively unmodified since European settlement. There have been no extinctions of vertebrate fauna (Woinarski & Braithwaite 1990), little secondary salinity or scald development, and rabbits and foxes are absent. Thus we have the opportunity to learn from the mistakes of southern and central Australia to ensure that economic development proceeds while sustaining the natural ecosystems and the productive capacity of the land. For the foreseeable future, the most widespread land use on the savanna of the north will remain grazing of cattle.

Most knowledge of the effects of land management on the processes of land degradation in Australia's northern savannas is based on large experiments at a few research stations. However, as yet, there is little scientific basis for extrapolating knowledge of processes across the vast areas of northern Australia which have a high degree of variability in rainfall and landscapes. In this paper, we describe a new research project which aims to provide that basis for the Top End of the NT above 18°S. This project has been funded for five years by the Land and Water Resources Research and Development Corporation. It is being conducted by the CSIRO with formal collaboration with CCNT.

#### RESEARCH APPROACH AND PROPOSED METHODS

This project is based on two main concepts. The first is that the responses of savannas to stress and disturbance depends on the extent of limitation and degree of variation in plant available moisture and available nutrients (*The PAM/AN plane*, Goldstein *et al.* 1988). Any given point on the PAM/AN plane approximately corresponds to a combination of a particular soil type at a particular level of mean annual rainfall. Secondly, the savannas at any point on the PAM/AN plane can exist in various stable or semi-stable states which can undergo transitions to other states in response to disturbance (*State-and-transition models*, Westoby *et al.* 1989).

The specific questions we seek to answer by this research include:

- 1. Can the structure, composition and production of natural vegetation in different landscape types be accounted for by the location of those landscapes on the PAM/AN plane?
- 2. Does actual and simulated grazing in a range of landscapes affect the PAM/AN location of any landscape? Does that change flow through to plant performance?
- 3. Can the observed responses of savannas to grazing be attributed to changes in the spatial and temporal distribution of soil water and nutrients?

For this research, we have selected a range of study sites which make use of the strong gradient in rainfall and the range of soil types that exist in the Top End of the NT. Study sites have been selected on sand, loam and clay soils in the Darwin region (c. 1600mm) and at Douglas-Daly Research Station

(c. 1250mm), Willeroo/Scott Ck. Stations (c. 1000mm), Kidman Springs (c. 750mm) and Mt Sanford Station (c. 500mm).

At each site the landscape ecology will be described in terms of geomorphic shape, patterning of the soils and vegetation, and soil properties. Experimental plots, each 20m X 20m, will be located at defined positions within the landscape. The soil of these plots will be characterised using a range of standard soil physical and chemical properties such as available phosphorus, cation exchange capacity and water holding capacity. These data will be coupled with rainfall records and other climatic data to place each study site on the PAM/AN plane.

For each combination of soil type and rainfall, the study sites have been selected with the vegetation and soils in as good a condition as possible. Three disturbance levels will be established and maintained in the 20m X 20m plots. The changes over time in vegetation and soil surface conditions in response to disturbance will be measured. The disturbance levels include stock excluded, ambient levels of grazing, and repeated defoliation early and late in the wet season. Vegetation properties which will be assessed include productivity, composition, and species diversity of the herbaceous layer, and woody recruitment. The soil surface will be assessed in terms of crusting, distribution of runoff and runon zones at appropriate scales, water infiltration rates, and structural stability.

Patterns of water movement and the interaction with vegetation will be assessed along belt transects of several hundred metres upslope and downslope from the study plots. This will put the smaller study plots within the broader context of landscape processes.

#### PLANNED OUTCOMES

One of the main outcomes of this work will be an assessment of the risk of degradation of a wide range of land types across the Top End. Combinations of soil type and rainfall which require more careful management for sustainable use will be identified as well as those which are more resilient. The processes by which degradation occurs will provide the basis for identifying early warning signs in susceptible land types. Furthermore, this study will separate the effects of grazing on vegetation alone, from changes in vegetation which result from changes in soil as a habitat for the pastures. This has major implications for restoration techniques.

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# PLANT DISTRIBUTION IN A SEMI-ARID EUCALYPTUS POPULNEA SHEEP RANGELAND WITH BOREDRAIN IN S.W. QUEENSLAND

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## INTRODUCTION

In the semi-arid sheep rangelands of south-central Queensland, open boredrains are a common water source. Landholders are currently being encouraged to pipe and trough all bore water and this is mandatory for all new bores. The plant distribution of semi-arid sheep rangelands in Australia have usually been examined with reference to point water sources, e.g. Andrew and Lange (1986), Pickup (1989), Bastin *et al.* (1993). Linear water sources are expected to be associated with lower stocking pressure than point water sources; as a result the stocking gradient is unlikely to be so acute and degradation associated is likely to be less severe. This paper analyses the effect of the placement of a linear water source on surrounding vegetation.

# **MATERIALS AND METHODS**

A paddock on a sheep property (North Yancho) 700 km west of Brisbane was selected for its uniform topography and soil type (red earth). This paddock has a linear water source (boredrain) parallel and adjacent to the Western fence. Data were collected in March 1993, the 3 km x 3 km paddock being divided into a logarithmic grid of 84 plots at 10m, 30m, 100m, 500m, 1000m and 1500m from each fenceline. Within each plot 30 randomly located 1 m squared quadrats were sampled for abundance and cover of all understorey species. Linear regressions were used to detect boredrain, fenceline and wind effects on plant species distribution.

## **RESULTS**

Plants could be divided into three groups; species whose relative contribution decreased with distance from the water, species that peaked at intermediate distances from the water and species that increased with distance from the water (figure 1a). Abundance of the *Chenopodiaceae* decreased logarithmically with distance from the boredrain (P<0.01),

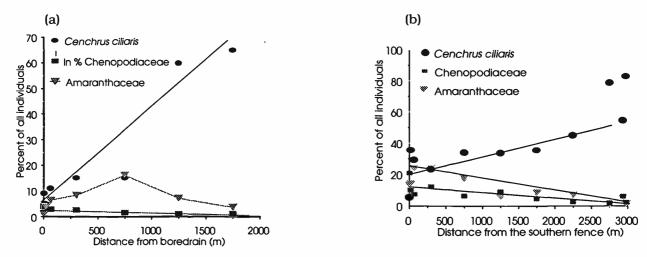


Figure 1. Change in relative proportions of *Cenchrus ciliaris*, Chenopodiaceae and Amaranthaceae with distance from the boredrain (1a) and distance from the southern fence (1b) (regression line excluding fence effected plots).

Cenchrus ciliaris increased significantly (P<0.002), and Amaranthaceae peaked at an intermediate point.

Lines parallel to the boredrain showed a distinct North-South and fence effect (figure 1b), relative abundance of Amaranthaceae and Chenopodiaceae diminishing on a South-North gradient (P<0.002, P<0.02), whereas those of *Cenchrus ciliaris* tended to increase from South to North (P<0.01).

#### **DISCUSSION**

Studies of point water sources report severe soil erosion and an almost complete loss of permanent plant cover around the water point (e.g. Andrew and Lange 1986). While there has been a significant species replacement over the stocking gradient out from the drain, this study appears to show a less marked degradation; trends being similar to North-South patterns.

Sheep camps were situated along the edge of the boredrain, compounding the water effect. In the absence of sheep camps, plant distribution associated with the boredrain would be more similar to fence induced trends.

The grazing of sheep into the prevailing southerly winds is thought to be primarily responsible for the low plant cover in the southern area of the paddock.

# **CONCLUSIONS**

The higher trampling and faeces input adjacent to the boredrain is thought to be the main factor controlling differences between boredrain and south fence effects. It appears that a linear water source is preferable to point water sources for maintenance of rangeland condition. As the stocking intensity at any one point along the boredrain will be much lower than that of point water sources, there is a trade off between conservation of water and conservation of native pastures: while it can not be argued that boredrains should not be piped, access to multiple water points is also important.

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# COMPARATIVE EFFECTS OF TIME CONTROL AND CONVENTIONAL GRAZING ON BOTANICAL COMPOSITION, SOIL PHYSICAL AND CHEMICAL PROPERTIES AND LEVELS OF BIOLOGICAL ACTIVITY

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#### **ABSTRACT**

A study has recently commenced in which the comparative effects of Time Control ("cell") Grazing and conventional grazing on pasture and soil attributes will be measured. Measurements will be made on the abundance, basal area, vegetative growth characteristics and flowering phenology of a range of important desirable and undesirable pasture components. These include perennial, annual, exotic and native species. Soil porosity, bulk density, water infiltration rates, nutrient status, organic carbon, pH, numbers of soil invertebrates and the activity of cellulose-decomposing bacteria and fungi will be measured at regular intervals. The level of selective grazing with respect to key components of the pasture will also be assessed.

# INTRODUCTION

Interest in Time Control or "cell" Grazing has increased significantly in recent years (Hacker 1993). Associated with this stimulated interest is a degree of controversy which has prevailed in the United States over the past decade and is currently being experienced in the Australian pastoral industry. A number of short term research projects comparing time control with continuous grazing have been conducted in the United States with mixed results with respect to livestock and vegetation responses (White *et al.* 1991). The same authors refer to the scarcity of long term research results. The major contribution to research into Time Control or "short-duration" grazing has been by Texas A&M University, most notably by Heitschmidt, Stuth, Taylor and Kothmann. The stocking rates used under short-duration grazing in these studies have commonly been 2 or 3 times the conventional stocking rates and the experiments were usually undertaken on small research station plots.

The concept of Time Control Grazing is a component of the management philosophy referred to as "Holistic Resource Management" (HRM) (Savory 1988). The grazing management principles advocated by Savory (1988) involve manipulation of four main ecosystem elements or "foundation building blocks"; succession, the mineral cycle, the water cycle, and energy flow. The grazing management system aims to achieve a desirable mix of species and abundance of pasture through short graze periods with high stock density to achieve better utilisation of available pasture.

A study has just commenced to test the effects of the principles advocated by HRM on a number of pasture ecosystems in the high rainfall zone of the Northern Tablelands of NSW. While the primary focus of the project will be vegetation response, each of the ecosystem "building blocks" will be examined in some detail in an attempt to achieve an understanding of the complex interactions which occur within a pasture ecosystem.

## **METHODS**

Four predominantly native pasture sites on commercial properties situated within the New England Tablelands region of NSW have been selected to conduct the study. At each of these sites, a new "cell" has recently been established where Time Control Grazing will be practiced and set stocking is implemented on adjacent areas. Site selection was primarily on the basis of similar botanical composition, soil type and aspect as well as similar management histories, particularly with respect to superphosphate application.

A series of permanent transects will be established at each of the sites in similar areas under each grazing management regime. Data to be collected from these areas will include:

\* The presence / absence of all species within each quadrat will be recorded to give a relative measure of plant frequency. Over time, this will enable determination of the vegetation response by building a picture of how the composition of the plots changes. Using a 100 point

quadrat, an absolute measure of basal cover of individual species will be obtained. Bare ground and litter will also be recorded. The persistence of species will be determined by these data. For a selection of dominant perennial grasses at each site basal area, vegetative growth characteristics and flowering phenology will also be monitored and these features compared between treatments and across sites.

- \* Soil chemical and biological properties will be measured at regular intervals to determine the "health" status of the soil. By monitoring total nitrogen, total organic and inorganic phosphorus, and organic carbon, estimation of changes in the nutrient pools of specific elements may be made. At similar intervals, soil biota counts will be made to determine the relationship between the fauna and the cycling of nutrients within each system.
- \* Infiltration rate, bulk density and air filled porosity will be measured regularly in order to evaluate the effect of the grazing systems on soil physical characteristics through time.
- \* Productivity measurements will be made for each system prior to grazing periods by cutting and weighing the material in quadrats. Crude protein content of the pasture will be evaluated on a seasonal basis, giving an indication of pasture quality.

# **ACKNOWLEDGEMENTS**

The financial assistance of the Meat Research Corporation in funding this project is gratefully acknowledged.

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# DEVELOPING GRAZING MANAGEMENT STRATEGIES FOR THE ARISTIDA-BOTHRIOCHLOA GRASSLANDS OF QUEENSLAND

Piet G. Filet' and Trevor J. Hall<sup>2</sup>

QDPI: 1Emerald and 2Roma

# **INTRODUCTION**

A review of the grazing lands of Northern Australia has estimated that 50% of the *Aristida-Bothriochloa* community is in sub-optimal condition (Tothill and Gillies 1992). Why and how this may have occurred can only be speculated. This heterogeneous native pasture community supports 1.2 million head (predominantly store cattle), covers 10.5 million hectares and is characterised by a eucalypt woodland overstorey. Currently there is little knowledge of species ecology or production in this community, information which is essential for developing grazing management strategies to either improve or maintain pasture condition. In this paper we outline an approach designed to develop viable grazing strategies for the sustainable use of this community.

## AN APPROACH TO DEVELOP GRAZING MANAGEMENT STRATEGIES

# Quantify pasture composition throughout the community

A diverse and highly variable native pasture composition is a striking feature of this community (Osten and Schefe 1994). This natural variability is linked with difference in soil, woodland type and climatic conditions. Differences in woodland development and grazing management are also factors influencing the variability in composition. To quantify these contrasts, an initial requirement is a quantitative description of pasture composition throughout the community. Current work is centred on the Central Highlands and Maranoa portions of the community.

Our survey approach aims to document the range in pasture composition. Parameter sets collected include: (1) floristics, i.e. species frequency, density and basal area estimate; and (2) soil surface condition, i.e. degree of crusting, erosion, litter accumulation and presence of cryptogams. Each site is also categorised in terms of soil and woodland type, current woody overstorey and understorey density and timber development history. Where possible near-by sites with contrasts in current or recent management practices, e.g. differences in timber treatment, grazing pressure or use of fire are compared. Contrasts in species composition will be determined by pattern analysis.

# Identify possible causes of change between different compositional states

Compositional states that optimise grazing production and are sustainable are highly desirable. Actions required to achieve such a state or causes that may result in a less desirable state are critical influences. Interim results from the survey and local experience have enabled a conceptual scenario, as per the "State and Transition" model, to be compiled (Hall *et al.* 1994).

In this woodland community, changes to the overstorey component (e.g. pulling or chemical treatment) have major effects on the potential grazing production of the native pasture component. Unsuccessful development results in timber regrowth which not only reduces pasture production, but increases the risk of degradation occurring, either through soil erosion and/or changes to less desirable pasture mixes. Complimentary to woodland development actions, are grazing management strategies such as fire and grazing pressure which will also influence the botanical composition and soil stability. The effect these management influences have on the rate of change between states requires quantification, as do the productive and sustainable value of each state.

# Evaluate the effects of major management influences in terms of changes in the pasture

An experimental approach enables changes in a pasture to be associated with imposed influences. For this community, change is considered best linked to the effects of grazing pressure, presence or absence of trees and fire. The imposition of these treatments over a minimum of five years provides the opportunity of contrasting seasonal effects to also influence change.

The parameter sets most likely to indicate change are: (1) floristics, namely composition and basal area at a paddock scale and plant recruitment, persistence and mortality at a plant demographic level; (2) pasture production, e.g. water use efficiency; (3) soil stability, e.g. runoff and erosion; (4) woodland dynamics, e.g. does tree basal area change; and (5) animal production, however inadequate animal numbers limits the confidence of this measure. Together these parameter sets will indicate if management actions, either in association or independent of seasonal effects, will maintain, improve or deteriorate the value of these pastures.

Development and testing of these management actions at a paddock scale will best refine these interacting influences for implementation at a commercial scale.

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# DETERMINING LONG-TERM SUSTAINABLE MANAGEMENT OF CHENOPOD SHRUBLANDS - BULGUNNIA STATION: A CASE STUDY.

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#### **ABSTRACT**

This paper reports initial results from a unique long-term re-evaluation of historical shrub-density survey work of R. Jessup, B. Lay and J. Maconochie in the sheep-pastoral country of northwest S.A. Results on Bulgunnia Station in 1993-94 reveal an encouraging positive condition trend in both the density of chenopod shrub populations in many paddocks, and the occurrence and extent of regeneration of the tree species surveyed, compared with the 1970-72 study.

# INTRODUCTION

Perennial chenopod shrubs provide essential forage for stock during periods when no annual or ephemeral pasture growth occurs, hence the management of these plants is essential in maintaining sheep production during periods of drought and low rainfall.

Bulgunnia Station is located centrally within the Kingoonya Soil Conservation District in north-west South Australia. Annual rainfall from 1955 to 1989 averaged 156 mm, however precipitation varies widely from year to year and with no seasonal tendencies. These episodic rainfall events are extremely important for the recruitment and onward growth of many perennial arid zone species (Noble, 1986).

A survey on the extent and condition of saltbush and bluebush pastures was initially carried out by R.W. (Fred) Jessup in 1948-49; and formed the basis for a study of long-term changes in these forage species by Lay in 1970-71. This survey is now being re-run by Maconochie from 1993. As Lay had done 23 years earlier, Bulgunnia was chosen to be the first station to be tackled in this project.

## **METHODS**

Bulgunnia Station is situated 140 kilometres north-west of Glendambo covering approximately 3207 square kilometres. The vegetation in the district is primarily a mosaic of chenopod shrubland and low Mulga or Western Myall woodland with a grassy or chenopod understorey.

The species studied in these surveys comprised *Maireana sedifolia* (Pearl Bluebush), *M. astrotricha* (Low Bluebush), and *Atriplex vesicaria* (Bladder Saltbush). Scattered overstorey trees examined in this study include *Acacia aneura* (Mulga), *A. papyrocarpa* (Western Myall), and *Callitris columellaris* (Native Pine).

The present survey was conducted using the methods devised by Lay (1972) and Jessup (1951). It has been necessary to refine the techniques of data acquisition and survey on Bulgunnia before attempting the remaining 16 leases in the survey area.

The data and notes of all three observers were entered into a database. The traverse routes taken by the observers were mapped using GPS co-ordinates and added onto base maps using the Arc/Info software. GPS co-ordinates were taken at 3 kilometre intervals, at photopoints and at geographical positions that could be identified on the ground (i.e. fences, gates, track junctions, water points). This will enable future surveyors to have accurate maps of the route for the collection of comparable data in the future.

To further allow a greater degree of success for future surveys, the traverses have been broken into "sections". A "section" is defined as a length of comparable traverse between two known geographical locations. Paddocks are now comprised of "sections", each section having a number and a comparable code within any one paddock. If a section (1) has data relating to Jessup, Lay and Maconochie it is coded as JLM 1, if data is for Lay and Maconochie it is LM 1.

#### **RESULTS**

Of a total of sixty four paddocks on Bulgunnia, analysable data were obtained from forty two paddocks on the present survey.

Initial analysis of the data was performed using results from JLM sections. Parts of Lay's original traverse which followed the routes of Jessup have been lost and other parts were new to the study.

Overall bush density changes in the last twenty years have shown a slight improvement, which contrasts with the significant reduction recorded by Lay over the previous twenty year period (1948-70).

A survey of one of the three tree species included in the survey, Mulga, showed similar trends, but an even more striking result. Whereas in 1970 recorded regeneration was limited, now extensive areas of young Mulga occur almost ubiquitously on this run. It has been observed, however, that no significant rabbit problems have occurred in recent years anywhere on this station.

#### **DISCUSSION**

Regeneration in the arid zone requires periods of good seasons and careful stocking regimes so as to make major positive impact on the surrounding systems.

The results over the last twenty three year period have shown a dramatic turn-around in the population dynamics of most of the perennial shrubs studied. This can be attributed to the careful management of the station during which time a drought was declared in 1976 and low rainfalls occurred during the period 1982-1984.

The almost complete absence of extensive rabbit infestations on this run over recent years must have also had a significant bearing on the extent of tree regeneration now evident.

Preliminary results have thus far shown that, predictably, both management practices, feral animal populations, together with favourable climatic conditions have affected the survival and regeneration of saltbush and bluebush stands, and of the Mulga overstorey. The recuperation of these shrublands as a result of these favourable management and climatic conditions has, however been slow and it will be many more decades at this rate before stands recover to the densities which occurred in the early days of settlement. The ultimate recovery of the longer lived species such as Pearl Bluebush depends on an infrequent episodic process, with a once-in-twenty year (or more) recruitment pattern (Wotton, 1993). Regeneration of Pearl Bluebush on Bulgunnia has been very significant in the last twenty years with good stands of young and mature plants occurring on many areas of the station. This can be attributed in part to a conservative stocking management policy with no more than 300-500 sheep being depastured on any one permanent watering point. This has allowed the germination and establishment of Pearl Bluebush seedlings during the years of exceptional rainfall during this period, particularly 1973-4, and 1989.

# **ACKNOWLEDGEMENTS**

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## BASAL AREA CHANGE IN ASTREBLA GRASSLAND -IN HARMONY WITH TRENDS IN RAINFALL AND GRAZING

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#### INTRODUCTION

Fluctuations in basal area occur in *Astrebla* grasslands due to variation in both seasonal rainfall and grazing pressure (Orr *et al.* 1986). Despite this, little is known of how individual *Astrebla* spp. tussocks respond to variation in rainfall or grazing pressure.

This paper presents interim results from a grazing study where changes in both the growth and survival of individual plants and the basal area of *Astrebla* spp. are interpreted in relation to seasonal rainfall and grazing pressure.

#### **METHODS**

A grazing experiment incorporating five levels of forage use was established in *Astrebla* grasslands near Julia Creek, Queensland. In May 1984, sheep numbers were set so that 10, 20, 30, 50 and 80% of the total forage available would be consumed in the treatment paddocks over the ensuing year. In April each year, the total forage available in each paddock is determined and sheep numbers are altered to maintain these levels of utilisation.

The demography of *Astrebla* spp. is monitored annually, during the dry season, by charting the position and diameter of individual tussocks in permanently located quadrats in the 10, 30, 50 and 80% utilisation treatments and basal area calculated from the number of tussocks and their diameter (Orr 1992).

#### **RESULTS**

The five year moving average for summer rainfall (Willcocks and Young 1991) was below average between 1985 and 1990 (Figure 1).

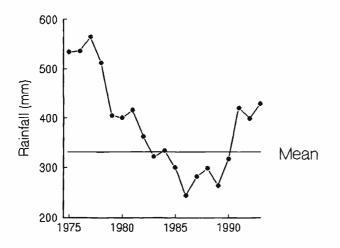


Figure 1. Five year moving average rainfall for summer (October - March) for Toorak between 1975 and 1993.

Basal area decreased from 1984 until 1989 (Figure 2a) in line with below average summer rainfalls and was independent of utilisation treatment. Since 1989, basal area has increased in line with above average summer rainfall (Figure 1). The largest and smallest increases in basal area occurred at the lightest and heaviest utilisations respectively. Much of the increase in basal area since 1989 resulted from the survival and growth of tussocks recruited (30 seedlings/m²) in 1989 (Orr 1992) (Figure 2b).

By 1993, both the survival and mean basal diameter of plants recruited in 1989 were greatest and least at the lightest and heaviest utilisations respectively (Figure 3). These differences are reflected in total basal areas.

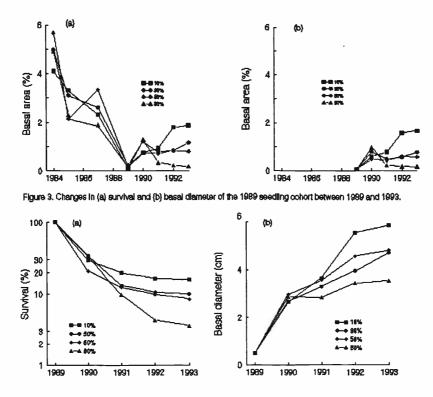


Figure 2. Changes in (a) total basal area of Astrebla spp. between 1984 and 1993 and (b) the contribution of 1989 plants.

#### **DISCUSSION**

Trends in seasonal rainfall and grazing pressure influenced basal area of *Astrebla* spp. However, for the full period of study (1984-1993), trends in rainfall influenced basal area more than grazing pressure. This finding is consistent with the finding (Orr and Evenson 1991) that seasonal rainfall is more important in determining basal area in these grasslands than moderate grazing pressure.

Heavy grazing has resulted in reduced plant survival and plant size. Continued heavy grazing will be detrimental. Given a continuation of favourable summer rainfall, we expect an increase in basal area to occur in the light and moderate grazing treatments.

Further monitoring of basal area in this grazing experiment is needed to determine whether differences in basal area will become apparent between the 30 and 50% utilisation treatments.

## **ACKNOWLEDGMENTS**

We are grateful for the support from Toorak staff in maintaining the study site and for financial support from the Australian Wool Corporation.

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## ESTIMATING PASTURE YIELD IN MITCHELL GRASSLANDS USING PHOTOSTANDARDS

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#### **ABSTRACT**

A simple yield estimation technique was developed for use both in the field and with photographic records. Graziers and researchers had expressed this need. Initial success with untrained operators using photostandards was better in the field. With training, estimation of yields from photographs or slides also proved successful.

#### INTRODUCTION

A simple, but relatively accurate technique was required to estimate the yield of mitchell grass pastures. Graziers had expressed this need to aid property management and a major research project needed historical pasture yields. Photostandards were seen as a possible solution to both problems; to provide a basis for paddock estimations and estimations from existing photographic records. Initial results of testing this method will be presented here. A poster will be presented at the conference to allow further testing.

#### **METHODS**

Eight photostandards were selected from records of a DPI grazing trial. Yields within the six trial paddocks had been estimated since 1986 using the dry weight ranking component of BOTANAL (Tothill *et al.* 1992). The photostandards were assumed to represent those yields, and selected to cover the range 100kg/ha to 4000kg/ha. A further 76 slides from the trial were used for initial yield estimates from photographic records. A large proportion of these were found to be unsuitable, and the final number was reduced to 28. For the initial testing, 15 operators viewed the slides, using the 8 photostandards for guidance. Three of these operators continued re-estimations, with the slides re-randomised between each viewing.

Ten operators were used to test the photostandards in paddocks with known yields (Tothill *et al.* 1992). Regression analysis was used to determine the accuracy of the techniques.

#### **RESULTS**

Original success of estimations of yields from photographic records was varied, but generally low.  $R^2$  values varied from 32% to 52% (Table 1).

Table 1. Initial R<sup>2</sup> values of estimation of yield from photographic records (R<sup>2</sup> based on 76 or 28 points).

R²	<50%	50-80%	>80%
no operators	11	4	0

Initial efforts at the paddock level were more successful (Table 2), with the lowest R2 being 63%.

Table 2. Initial R<sup>2</sup> values of estimation of yield in the paddock (R<sup>2</sup> based on 6 points).

R²	<50%	50-80%	>80%
no operators	0	4	6

Estimation of yields from photographic records improved for the 3 (out of 15) operators available to continue testing (Table 3).

Table 3. R<sup>2</sup> values increased from initial testing, the intercept approached zero.

	Initial R²	Initial Intercept	Final R²	Final Intercept
op 1	32%	805	63%	372
op 2	46%	615	60%	507
op 3	58%	323	79%	160

Operators 2 and 3 were combined ( $R^2 = 84\%$ ) to estimate yields from photographic records. The regression equation was:

yield  $(kg/ha) = 130.930 + 0.68843 \times OP3 + 0.26744 \times OP2$ 

## **DISCUSSION**

The initial success of estimating yields was greater in the paddock than from photographic records. This is primarily because pasture height, tussock density and pasture bulk can be more accurately gauged when the operator is physically present in the paddock. The high R² values are encouraging, although they do not tell the full picture as some operators consistently over or under estimated pasture yield in the paddock. The use of the photostandards should provide a "ball park" yield estimation useful to graziers and for extension activities.

Estimations from photographic records improved with training, practice and removal of unsuitable slides. Some slides proved unsuitable due to: too much or too little horizon, under- or over exposure, photograph not representative of paddock yield, and poor focus. These can all be overcome with improved camera technique and better positioning of photo-sites. The upper limit of individual operator accuracy was around 80%, with some inherent over or under-estimation. This was improved by pooling operator estimations into one regression equation.

## **ACKNOWLEDGMENTS**

We wish to thank the other 21 people who took part in this testing, and the NLP and the AWRAPO for funding the projects which this work drew from, and contributed to.

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## MANAGEMENT OF GRAZING PRESSURE TO MAXIMISE WATER INTAKE AND MINIMISE SOIL MOVEMENT

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#### **ABSTRACT**

Grazing pressure, through its effects on the soil surface and plant cover, affects rainfall infiltration and hence runoff and soil movement. The effect of this process on black speargrass (*Heteropogon contortus*) were studied at a range of scales. Soil surface hydrological characteristics under varying stocking rates and pasture composition were determined using a disk permeameter and rainfall simulator. Integration of the process was measured using small plots (60-80 sq m) and larger landscape plots (0.4 ha) measuring runoff and soil movement. Changes in species composition were found to be related to changes in pore size distribution, with a loss in 1-3 mm pores under *Aristida spp.* or annual grasses. Total runoff and peak runoff rates were reduced if *H. contortus* was maintained. The small plots showed an increase in runoff and soil movement as stocking rates increased, but this localised effect was not translated to the landscape scale.

#### INTRODUCTION

Variation in grazing pressure has a direct influence on the soil surface and over a longer period the pasture composition. These changes in soil surface hydrologic characteristics affect rainfall infiltration rates and runoff. If increased runoff is associated with a disturbed soil surface, increased soil movement will result. Major areas of southern black speargrass (*Heteropogon contortus*) pastures have shown changes in pasture composition, with the development of patches of *Aristida spp.* and/or annual grasses in the naturally dominant speargrass pastures. This study examines the changes associated with this patch development, from the patch scale (m²) through to the landscape runoff generation scale (ha).

#### **METHODOLOGY**

The study was carried out on two existing grazing experiments, one at 'Glenwood', west of Mundubbera and the other at 'Galloway Plains', west of Gladstone.

The treatments at Glenwood are three stocking rates (0.0, 0.6 and 0.9 steers/ha), two land classes (narrow-leaved and silver-leaved ironbark) and two patch types (one dominated by *H. contortus*, the other by *Aristida spp.*). The treatments at Galloway Plains are three stocking rates (0, 0.25 and 0.5 steers/ha) and two pasture types (perennial grasses dominated by *H. contortus/Bothriochloa bladhii* and annual grasses). Silver-leaved ironbark is the dominant overstorey.

Runoff and infiltration parameters were determined at both sites using a rainfall simulator and calculated by a modified Green and Ampt equation. Pore size characteristics were determined using a disc permeameter.

At Glenwood, large landscape runoff plots (20 m wide and 150-200 m long) encompassing both the narrow-leaved and silver-leaved ironbark communities were installed for each stocking rate. Smaller replicated plots (10 m wide and 5-7 m long) were installed in each of the land classes. At Galloway Plains large plots were implemented on each of the stocking rates. Runoff from the plots was recorded by either a 4 litre tipping bucket at one minute intervals for small plots, or a 150 mm Parshall flume at two minute intervals in the landscape plots. Soil movement was measured by collection of the deposited sediment in a catch trough along the bottom of the plot.

#### **RESULTS AND DISCUSSION**

Mean hydraulic conductivity values for patch type and land class over a range of stocking rates at -1 and -3 cm H<sub>2</sub>O of applied suction for the Glenwood and Galloway Plains sites are given in Table 1. At both locations pores between 1 and 3 mm in diameter are a major contributor to the hydraulic conductivity in the *H. contortus/B. bladhii* patches (36 of 77; 154 of 182 mm/hr). In the adjacent *Aristida spp.*/annual grasses patches the number of pores in this range had been reduced, such that the contribution to hydraulic conductivity has been markedly reduced (25 of 59; 32 of 56 mm/hr).

Table 1 Hydraulic Conductivity (mm/hr) at the applied suction derived using a Disk Permeameter for Galloway Plains (xx) and Glenwood (yy).

Treatment				Head	l (cm H	[ <sub>2</sub> O)			Δ	К
reautent	Pore diameter (mm)				Po					
		<	3.0			<	1.0		1-31	nm 
Patch Type H. contortus/B. bladhii Aristida spp./Annual grass	182 56	a b	77 59	a b	28 24	a a	<b>41</b> 34	<b>а</b> а	154 32	36 25
Land Class Narrow-Leaved Silver-Leaved			44 93	a b			28 47	a b		16 46
Stocking Rate 0.0 b/ha 0.6 b/ha - 0.25 b/ha 0.9 b/ha - 0.5 b/ha	194 111 53	a b c	99 30 76	a c b	30 22 27	a a a	59 17 36	a c b	164 89 26	40 13 40

Means followed by the same letter are not significantly (P<0.05) different between treatments for the same head.

 $\Delta K$  = change in hydraulic conductivity (mm/h)

At the Galloway site there is a marked stocking rate trend. The -1 cm head values are much higher for the exclosure than for the high stocking rate site (194 vs 53 mm/hr). This trend occurs for both the perennial grasses and annual grass sites. However, there is no clear stocking rate effect at the -3 cm head (30 vs 27 mm/hr) indicating a marked loss of 1 to 3 mm pores as stocking rate increases. At Glenwood there is no clear effect.

The disc permeameter results generally mirror the results from the rainfall simulator. The peak rate of runoff at the Glenwood site for the *Aristida spp*. patches was much higher than for the *H. contortus* (17.9% vs 2.8%). There was also a higher peak rate of runoff from the narrow-leaved (12.4%) than from the silver-leaved ironbark (4.3%) plot. Stocking rate did not have a major effect, although the peak rate of runoff from the heavily grazed site was significantly greater than from the exclosure (15.1% vs 3%). Total runoff and peak runoff rates are much higher for the Galloway Plains site. Peak runoff rate and total runoff was lower on the perennial grass patches than on the annual grass patches (51.3% vs 79.7%; 29% vs 58.8%). There was no effect of stocking rate.

When the runoff process is enlarged to the plot scale similar effects are still found. On the small plots only three rainfall events produced significant runoff, due to the historically dry conditions, although minor runoff occurred frequently when significant rainfall fell on a dry catchment. Grazing pressure had a marked effect on runoff in the small plots; the higher the stocking rate, the higher the runoff. However the runoff events from the small plots did not translate into significant runoff in landscape plots; that is runoff was localised within the catchment. This source/sink effect within the landscape plot indicates the importance of spatial distribution of the grazing patches.

A limited number of sediment producing events have occurred. The small plots indicate a clear stocking rate effect, with reduced grazing pressure resulting in a marked reduction in soil movement. At the higher stocking rate, landscape position affects the rate of soil movement. The upper slope plots (narrow-leaved ironbark) have higher soil movement than the lower slope plots (silver-leaved ironbark). No significant differences have been recorded at the medium or zero stocking rate.

## CONCLUSION

The results show that the process of runoff generation and soil movement is markedly affected by the management of grazing pressure, leading to changes in pasture composition. The mechanism of this change is indicated, with changes in the soil hydrological characteristics being a major component in producing increased runoff at a high stocking rate. An important consideration is the time it will take to reverse the changes that occur under periods of high stocking, or if these changes are permanent to the system.

## REFERENCE AREAS FOR MONITORING AND ASSESSMENT OF THE AUSTRALIAN RANGELANDS: A PRAGMATIC APPROACH

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#### **ABSTRACT**

Reference areas for evaluating range condition and separating out the impact of stock grazing from other environmental factors are traditionally climax, pristine or non-grazed areas, based on the succession - climax theory of ecosystem dynamics. My studies revealed that the reference area concept is unrealistic for rangeland management purposes. To be useful, a reference area should be a "well managed" rangeland. The concepts of "average" and "representative" sites are not useful for monitoring either, given the highly diverse nature of rangeland systems. By incorporating the piosphere model of stocking impact and the "State and Transition" model of rangeland dynamics, I propose a way forward for monitoring of range condition.

#### PROBLEMS WITH THE CONCEPT AND THE USE OF REFERENCE AREAS

Climax and pristine areas for Australian rangelands are difficult to define. Even in areas that have never been grazed, the pre-European condition no longer exists because of other changes in the environment (e.g. fire regime, exotic plants and animals, and global climate changes). Thus the notion of a pristine situation is unobtainable. In any case the non-grazed condition is not necessarily the desirable state for animal production; reduction of stocking intensity or total exclusion may not necessarily lead into a more desirable condition either. In the use of reference areas for environmental impact assessment, the basic assumption is that the original conditions of the impacted and the reference sites were similar, along with the magnitude of the other environmental factors and the response of components of those sites to those factors. In the Australian rangelands these conditions may hold for only limited time at best.

## WELL MANAGED RANGE THE BEST REFERENCE AREA

A more pragmatic reference area for the rangelands is a "well managed" area. But the limitations of our knowledge do not allow us to determine what are the criteria for well managed conditions for each of the many and varied types and situations in our rangelands. In most rangelands the perennial forage plants provide drought fodder and maintain soil stability; thus, their presence and vigour under "lightly" or "moderately" grazed condition may be regarded as indicating the "well managed" state. However the problems associated with comparing target sites with "reference areas" remains unsolved.

## NON REPRESENTATIVENESS OF THE MONITORING AND ASSESSMENT SITES

The general patterns and processes of the Australian rangelands can be recapitulated as: very high spatial and temporal diversity; event driven vegetation dynamics; and selective and patchy grazing (often focussed on watering points), superimposed over an already variable landscape. Thus no single site can be chosen as representative or average of the whole paddock, nor is the statistical average of many samples very meaningful.

## MONITORING SITES FOR PADDOCKS WITH PROMINENT SACRIFICE AREAS

For current managerial purposes, reference areas are not necessary. However a simple monitoring method could be very helpful for managers to observe degradation and react accordingly. On stations in which severe damage occurs by development of distinct sacrifice areas, e.g. within piospheres, the rate of enlargement of those areas can be regarded as the rate of degradation in the paddock. Therefore, what should be monitored is the process of degradation revealed as the enlargement of the sacrifice area. The basic management goal should be to prevent the growth of those degraded areas. The general criteria for the proposed monitoring sites is based on the "State and Transition" model of degradation within the piosphere framework (Hunt, 1992). What I propose is that the monitoring

site in each paddock should be in a zone where the vegetation is at its threshold condition and thus most responsive to combined effects of the climate and grazing management (Zone III, Fig. 1); the status of the major perennial forage plants will be the focus of monitoring. This proposed idea is only a concept, and field tests are required.

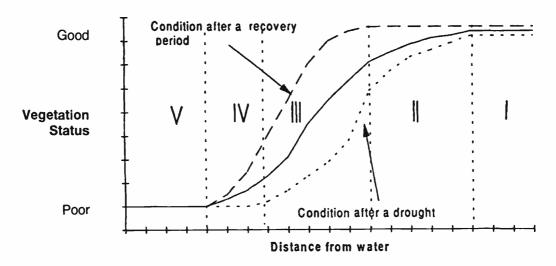


Fig. 1. The degradational stages of the main perennial forage plant populations at the piosphere.

Zone	I		Lightly grazed "stable state"
Zones	II-IV	II III IV	are "Transitional": Moderately grazed Heavily grazed "threshold" degraded
Zone	v		Shrubs removed "stable state"

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## RANGE CONDITION AND TREND (APPLIED)

(Poster Group Four)

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## USE OF NOAA AVHRR SATELLITE IMAGERY TO IMPROVE FIRE MANAGEMENT IN THE TOP END OF THE NORTHERN TERRITORY

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#### INTRODUCTION

This project was undertaken as a trial, in the Top End, of the satellite image processing procedures used for monitoring the fire mosaic in central Australia (Allan, 1993). The aim of the project was to develop a monitoring and reporting methodology that is suitable for the dynamic nature of the tropical savanna ecosystems and provides a regional overview to meet the needs of the Bushfire Council as the regulatory body responsible for fire management in the NT. This paper describes our methodology for processing a series of NOAA AVHRR satellite images and our results for the 1993 Dry Season. It also describes our plans to continue and improve the program over the next 3 years.

#### **METHODS**

NOAA AVHRR satellite images were purchased from NASIS in Townsville as unrectified digital data. Images were purchased at monthly intervals beginning with the first cloud-free image available after the end of the Wet Season. The data were processed using the microBRIAN image processing software by the Fire Ecology and Remote Sensing Unit of Wildlife (S) in Alice Springs.

The images were rectified and matched to the NT Pastoral Map. The spectral pattern of fires in the Top End are significantly different from those in central Australia so our first step was to investigate the reflectance characteristics of fire mosaics. All 5 channels were examined with reference to known features of the environment to interpret their variability. A combination of channels 2 and 3, and the calculation of a ratio channel of channel 3 + channel 2 / channel 1 were found to be most useful for discriminating burnt areas.

For each image date the burnt areas for the whole image were classified using training areas located in selected fire patterns. The classified image was then visually checked to eliminate anomalous areas. After each image was processed the Bushfire Council was provided with a thematic map of burnt areas stratified by image date. An accompanying table listed the number of pixels classified as burnt with the corresponding area in km². At the end of the Dry Season the image data were exported from microBRIAN to the ARC/INFO GIS. With the complete 1993 fire mosaic on the GIS, ARC/INFO was used to prepare a series of higher quality map products and more detailed statistical summaries by date, Bushfire region and vegetation community.

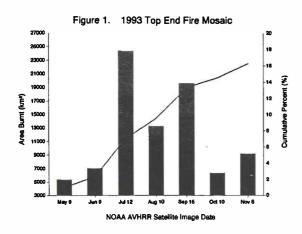
## **RESULTS**

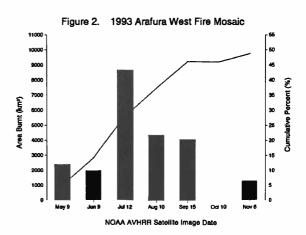
The first relatively cloud-free image available was not until early May. By this date the Dry Season was well underway and many fires had already occurred. There were four obvious smoke plumes on the image from active fires, including one associated with the Bushfire Council's aerial incendiary operations west of the Stuart Highway between Larrimah and Daly Waters.

The images purchased for June, July, August and September were relatively cloud-free images and simple to process. The Wet Season buildup started in early October and it was necessary to purchase two images in both October and November to create a relatively cloud-free mosaic image for each month. Persistent cloud in several areas restricted our ability to identify the total area burnt for each month. Fortunately the Bushfire Council indicated that the number of fires had decreased from the middle of the Dry and the potential for errors of omission was reduced.

Figure 1 shows the area burnt for each of the seven image dates and the cumulative percent for the area of the NT north of -18°. It highlights the dramatic peak in fire activity in the June / July period and also indicates a second peak in September which is associated with large and undesirable late Dry Season fires.

In contrast to Fig. 1, Fig. 2 shows the same information for the single Bushfire Council region of Arafura West. It is an example of one of the more populated and intensively managed areas of the Top End. The region covers the Douglas/Daly area and extends as far east as Kakadu National Park. Nearly 50% of the region was burnt although it missed the large late Dry Season fires. Similar patterns were recorded for the Vernon region surrounding Darwin, the Katherine region and Kakadu National Park with the cumulative total area burnt during the season being 49%, 44% and 36% respectively.





#### DISCUSSION

This trial has demonstrated the value of NOAA AVHRR imagery for regional monitoring of the fire mosaic of the Top End during the Dry Season. The persistence of clouds both early and late in the Dry Season was not significant enough to restrict the image processing methodology. The project was done without any ground truthing, but our experience allowed us to identify and map most burnt areas, with the exception of some errors in the floodplain ecosystems.

Our plan is to extend the program for the next 3 year period from 1994. The Regional Fire Control Officers (RFCOs) will take a more active role in ground verification, especially for small fires. They will review and field check the fire mosaic maps and provide GPS data for the location of some specific fires including their aerial incendiary operations.

Ancillary GIS information such as the NT Vegetation Map will be used to improve the image processing procedures to discriminate burnt areas for specific vegetation communities. The GIS data will also improve our interpretation of the fire mosaic. Over time we anticipate patterns will emerge that will characterise the nature, frequency and timing of fires in specific vegetation communities. The location of fire sensitive communities within the fire mosaic will be used to guide fire suppression activities.

It must be realised that the overall procedure is aimed at providing regional information. The timeliness and accuracy of the data will not necessarily meet the information needs for intensive fire management such as suppressing a specific fire or developing a fire management program for one of the National Parks in the region. It will however allow the Bushfire Council and other land management agencies to maintain an awareness of the nature and characteristics of each fire season. It will also provide base information to develop a better understanding of the contribution of fire to the issue of atmospheric emissions and regional air pollution (Beringer, 1993).

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Beringer, J. (1993). The Extent of 1992 Dry Season Biomass Burning and Associated Atmospheric Emissions in the Northern Territory, Australia. *B.Sc Honours Thesis*, Dept of Geog. and Environ'l Science, Monash University.

# PROBLEMS WITH ESTIMATION OF CONSERVATIVE CARRYING CAPACITIES FOR GRAZING PROPERTIES IN SOUTH WEST QUEENSLAND

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#### **ABSTRACT**

Johnston *et al.* (1992) presented a model for the estimation of safe carrying capacities for a range of land systems in south west Queensland. Validation against benchmark properties in the area has shown the need to improve the estimation of effects of woody vegetation on potential forage production. It has also highlighted some problems with the application of rainfall use efficiency values with land systems mapped between sheets in the WARLUS survey.

## INTRODUCTION

Johnston et al. (1992) presented a model for the estimation of safe carrying capacities for a range of land systems in south west Queensland. Elaboration of this model has produced Rainfall Use Efficiency values (kg/ha/mm rainfall) for land systems mapped in the Western Arid Region Land Use Survey (WARLUS). These, combined with 70-percentile rainfall values, have been trialled on benchmark properties, and found to give estimations of carrying capacities similar to those derived from long-term stock records on the properties. Work is underway to test the methodology over a wider range of properties. This is being undertaken by graziers acting as consultants in a project funded by Queensland Department of Lands. This paper reports some areas where problems have surfaced in this trialling.

## RESULTS AND DISCUSSION

Problems have been encountered in the following areas:-

## (a) Land System Mapping

Within the area mapped by WARLUS, land systems are mapped in considerable detail. Problems have been encountered in applying RUE values across mapping sheets. It appears that this may be resolved by reorganizing land system nomenclature across the sheets involved and deriving RUE values for all the resulting classifications.

A second area of concern is in application of the system to areas where land systems were mapped in less detail.

## (b) Effect of woody vegetation on potential pasture production

The general effect of increasing woody vegetation is to reduce pasture production (e.g. Beale 1973). Relations have been derived for both trees and shrubs for this project. Sites with both tree and shrub populations are being under-estimated in carrying capacity by the current system, thus indicating an area for further work.

## **ACKNOWLEDGEMENTS**

Field trials of the system are being undertaken by graziers acting as consultants to Queensland Department of Lands. Problem areas are being researched in a project supported by the National Landcare Program.

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## A GRAZING MANAGEMENT STRATEGY TO PROMOTE SUSTAINABILITY OF THE RANGELANDS

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#### **ABSTRACT**

A grazing management strategy (GMS) is described as a method of determining stocking rates in a biome where rainfall is highly variable, there is a high incidence of drought and where rare climatic events have a major influence on composition of vegetation. The GMS assesses the quantity of biomass at the end of the growing season and makes allowances for unavailable pastures, non-domestic grazing pressure, condition of pasture, unpalatable biomass and the physical layout of paddocks.

## INTRODUCTION

Overstocking the rangelands has contributed to the invasion of woody weeds and unpalatable pasture over vast areas (Tothill & Gillies 1992). The use of long-term carrying capacity to set stock numbers has clearly contributed to land degradation, loss of desirable species and reduced productivity. If the current stock management principles continue the long-term productivity of these dynamic and unique pastures will be threatened. The GMS is an adaptive management concept based on maintenance or enhancement of the resource, pasture monitoring, risk reduction, economic productivity, education of graziers and promoting conservation of the ecosystem.

**Maintenance or enhancement of the resource** depends on the capacity of the GMS to estimate safe grazing capacity, interpret the effects of paddock layout on grazing distribution, estimate the intake of domestic and non-domestic animals and in its accuracy in predicting rainfall.

a) Grazing capacity. Inter-seasonal variability in forage production is related to annual rainfall. Furthermore, C of V of mean annual rainfall for the rangelands is high and inter-seasonal changes in forage production are marked. The GMS determines available pasture at the end of each growing season by determining total biomass and assessing what proportion of that is unavailable (see Figure 1).

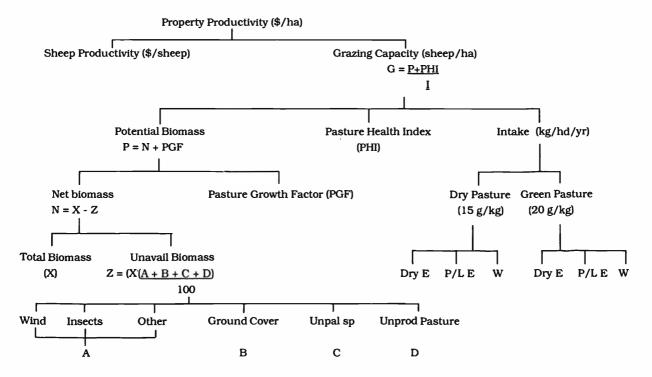


Figure 1. Inference tree of a grazing management strategy to calculate grazing capacity.

- b) Physical layout of paddocks in relation to water points, size and shape of paddocks and location and quantity of plant species will influence the grazing distribution of stock. A decision support system (Paddock) can be used to assess grazing distribution of sheep.
- c) Intake of pasture by sheep and kangaroos will be estimated. The GMS tests methods of monitoring kangaroo populations on property and making adjustments for pasture that they consume.
- d) *Predicting rainfall*. The GMS will incorporate available technology to predict intra-seasonal rainfall (*Rainman*, SOI) and estimate pasture growth (*Gunsynd*, *Grasp*).

**Monitoring.** Most graziers keep rainfall records, many keep records of animal performance (wool production, vegetable fault etc) and some keep records of their management decisions but few objectively monitor their pastures. The adoption of GMS will require the monitoring of pasture biomass and species frequency (condition assessment). This information, in conjunction with management and rainfall records, provides the quantitative information necessary to interpret the processes likely to cause transition between pasture and woody weed 'states'.

**Risk reduction.** GMS reduces the risk of poor property management by providing the necessary infrastructure to enable detection of an early pasture deficit or drought alert. This enables the sale of stock before a downturn in their condition or in market prices.

**Economic productivity.** Adopting the GMS will in many cases lead to a lowering of the stocking rate with a resultant increase in per head productivity, reduced variable costs and improved profitability. In the current market situation of low commodity prices, where the difference between per head income and variable costs is small (negative in many cases), reducing stock numbers on heavily stocked properties is a sound economic management decision.

**Education of, and collaboration with, graziers.** Graziers will be taught and encouraged to use simple monitoring techniques on their properties.

**Promote conservative management of the ecosystem.** The GMS is a positive attempt to manage the land on the basis of what the pasture/soil has produced, not on its potential to produce.

## **SUMMARY**

The GMS, and the grazing capacity it determines, expands the utilisation concept of setting stocking capacity by estimating total grazing pressure, intake, unavailable and available biomass, a ground cover threshold and pasture condition. Adoption of the GMS will limit land degradation and significantly reduce the incidence of unpalatable species and the establishment and spread of woody weeds. Furthermore, it will enhance the sustainability of production and economic competitiveness of primary industry. The objective nature of the strategy is likely to satisfy fellow Australians that the resource is being managed to preserve our national heritage so future generations have similar opportunities.

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## CONDITION AND TREND IN THE MULGA SANDPLAINS OF SOUTH WEST QUEENSLAND

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#### **ABSTRACT**

This paper reports observations collected from two monitoring sites on the mulga sandplains of south west Queensland. It describes the combined effects of seasonal rainfall, fire and grazing on the forage biomass, mulga and shrub communities at two sites near Hungerford on the Queensland-New South Wales border between 1980 and 1992.

#### INTRODUCTION

Initial concern over the deterioration of ground cover and the future productivity of mulga country was expressed by Ratcliffe (1937). Roberts (1972) pointed out that there was a need for long-term condition and trend information which would provide reliable data for the assessment of pastoral lands. In the mid 1970's this concern led to the establishment of permanent monitoring sites across the mulga lands of south west Queensland.

#### **METHODS**

Two sites in similar condition were selected on the 'Eulo mulga sandplain' land system (WARLUS Part 1). Data collected from both 500 metre by 5 metre belt transects include photographs, species composition, shrub and tree details, forage yield and rainfall.

Site 1 was burnt by a natural bushfire in December 1979. Site 2 was not affected by the fire. Monitoring began at both sites in 1980 and is ongoing.

## **RESULTS**

Site 1 pasture biomass levels ranged from approximately 1000kg/ha in 1984 to approximately 50kg/ha in 1992. Shrub density (*Eremophila sturtii*, *Dodonaea attenuata* and *Senna artemisiodes* var *nemophila*) increased from 572 plants/ha in 1980, following the fire, to 896 plants/ha in 1992. Mulga (*Acacia aneura*) density decreased from 136 plants/ha in 1980 to 16 plants/ha in 1992. *Eremophila gilseii* (green turkey bush) was not reported at the site following the fire.

Site 2 pasture biomass ranged from approximately 892kg/ha in 1984 to approximately 50kg/ha in 1992. Shrub density was maintained at 148 plants/ha in 1980 and 156 plants/ha in 1992. Mulga plants increased in population from 133 plants/ha in 1980 to 204 plants/ha in 1992. *Eremophila gilseii* maintained a density of 10,000 plants/ha.

## **DISCUSSION**

On site 1 it would appear that the fire had a major effect on mulga and green turkey bush densities, reducing the populations whilst encouraging improved pasture performance. This is supported by Sullivan and Pressland (1984). However the other shrub population (*Dodonaea*, *Senna*, and *Eremophila* species) increased in number dramatically over the period of observation.

Site two demonstrated the effect of seasonal variability and grazing pressure as little overall change in mulga, green turkey bush and other shrubs was recorded over the twelve years. Pasture biomass was not as high as that recorded on the burnt site however it did relate directly to seasonal rainfall.

Table 1. Change in shrubs and Acacia aneura.

YEAR	SHRUBS plants/ha (a)	Acane plants/ha (b)	
Site 1			
1980	572	136	
1984	1296	12	
1992	896	16	
Site 2			
1980	148	133	
1984	352	472	
1992	156	204	

(a) \* Dodonaea attenuata (Narrowleaf hopbush) \*Eremophila sturtii (Turpentine) \*Senna artemisioides var nemophila (Cassia) (b) \* Acacia aneura (Mulga)

Table 2. Estimated biomass.

Year	Biomass (kg/ha)			
	Site 1	Site 2		
1982	609	455		
1984	1000	896		
1987	580	125		
1990	255	43		
1991	234	53		
1992	50	50		

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# GRASS CHECK GRAZIER RANGELAND ASSESSMENT FOR SELF-SUSTAINABILITY

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## SUMMARY

Native pastures cover 87 per cent of Queensland - about 150 million hectares. They are an important resource for the State, contributing significantly to its economy and supporting about one-third of its primary producers (Lloyd and Burrows 1988). Forty two per cent of Queensland's rural exports derive from native pastures (ABS 1991).

However, of Queensland's native pastures, about 42 per cent are in a sustainable condition, 41 per cent are deteriorating and 17 per cent are degraded (Tothill and Gillies 1992). The need for a simple and objective pasture monitoring system for graziers led to the development of *GRASS Check: Grazier Rangeland Assessment for Self-Sustainability*. This paper outlines *GRASS Check*, how it works, its links with other programs and its current stage of development in Queensland.

## GRASS CHECK: GRAZIER RANGELAND ASSESSMENT FOR SELF-SUSTAINABILITY

Changes in pasture and soil condition that occur slowly but surely, such as weed invasions, pasture decline and compacted soils, often go unnoticed until they reach a serious stage. They often have serious affects on production but at this stage, rehabilitation can be a lengthy and costly process. Only careful grazing management will ensure their condition is maintained or improved, not only for now but for future productivity and prosperity. Graziers need a process where they are able to monitor and record these changes on their own properties so this later stage is not reached.

GRASS Check is a pasture monitoring program for graziers developed by the Department of Primary Industries (DPI), and Queensland graziers. It is a simple way of checking and recording the condition of pasture, timber and soil in paddocks anywhere in the State. GRASS Check assists graziers to manage native pastures more effectively and make well-informed property decisions.

## HOW GRASS CHECK WORKS

The GRASS Check package consists of a binder, introductory booklet and procedure sheets, which provide background information and ways to monitor pastures. It is very flexible and user-friendly - the introductory booklet provides background information while separate procedure sheets let the user choose between methods. The loose-leaf binder allows for easy additions of information or separation of sheets for use in the paddock.

At permanent *GRASS Check* monitoring sites on their properties, graziers have the choice of monitoring their pastures using photographic records, grazing records, estimates of standing feed, ground cover, pasture composition, woody plant densities and soil surface condition. Monitoring these aspects will provide warnings of feed shortages, weed encroachment, loss of palatable grasses, bare areas, erosion and compacted soils. If detected early, these problems may be overcome by altering management practices. Graziers may find *GRASS Check* helps them closely observe these changes, understand how they affect production, and consequently to make well-informed property management decisions.

## LINKS WITH OTHER PROGRAMS

Pasture monitoring is an important part of effective decision-making for graziers, so GRASS Check is closely linked with Property Management Planning (PMP) in Queensland. GRASS Check introductory workshops are being run across the State, either separately or as part of PMP workshops.

GRASS Check has an important role in landcare. It sits alongside the Grazier Guides to Managing Native Pastures (Partridge 1992) being produced for all major pasture communities in Queensland. It has close links with the Mulga Assessment Program (Evenson 1992), and the Pasture Watch program (Forge 1992), in which school students work with graziers to study pastures. These links will ensure GRASS Check is well-supported and relevant to graziers' needs.

#### THE CURRENT SITUATION

The monitoring methods used in *GRASS Check* were tested in the field by graziers, extension officers and pasture agronomists. It was released during February of 1994, and during March a series of DPI staff training days were run. These allowed extension officers to become familiar with the package and ways in which it can be used. Consequently, graziers interested in pasture monitoring can be confident that data they collect will lead to useful conclusions and well-informed management decisions.

### **ACKNOWLEDGMENTS**

The authors thank the many DPI staff from both the Land Conservation and Agricultural Production units who were involved in the development of the *GRASS Check* document and program. Queensland graziers have provided valuable feedback throughout the development of the program.

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## THE RANGELAND SURVEY PROGRAMME - PROCEDURES, PRODUCTS AND APPLICATIONS

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#### INTRODUCTION

Within the state of WA there are about 940,000 square kilometres of arid and semi-arid land which is currently held in 540 pastoral leasehold properties and used for the grazing of cattle and sheep.

To assist in the management of such a large area of our State (40%) the Pastoral Board, which is responsible for leasehold administration, has commissioned the Departments of Land Administration and Agriculture to establish a programme to survey and map the resources of the pastoral rangelands.

Prior to this the CSIRO, through its Land Research Series, conducted inventory surveys in the pastoral areas. However in 1972, the two departments took over the programme and introduced a system whereby the condition of the country could also be recorded.

## **PROCEDURES**

The surveys are conducted on a regional basis each typically in the order of 100,000 square kilometres. Pre-existing data are then collated and these would usually consist of:

- \* aerial photography at 1:50,000 scale (often flown specifically for the project)
- \* Landsat TM imagery rectified in 1:100,000 mapsheet format
- geological mapping and reports
- topographic mapping (updated from the aerial photography)
- \* cadastral mapping from lease documents and ground surveys
- historical books, plans and documents
- any specialist regional environmental reports

Field work is organised for coverage in the order of 1,000 square kilometres per day. This is achieved by vehicle traverses approximately 100km in length during which land system boundaries are ground truthed, and subjective assessments of perennial vegetation condition and the type and extent of any erosion are recorded at each kilometre. A number of 'inventory' and 'condition' sites are also chosen for more intensive sampling by the accompanying second team.

#### **PRODUCTS**

Primarily the survey product is a two-part regional report and map series which in the first volume deals with the resource of the area from a general perspective, whilst the second volume contains information on the condition of the country in a pastoral context. Individual pastoral lease reports tabulate areas of country type available for grazing and an estimation of their carrying capacity.

The report contains specific chapters on:

- \* land management recommendations
- brief pastoral history
- \* climate
- geology and geomorphology
- hydrogeology
- vegetation
- weeds and vertebrate pests
- survey methods
- \* soils
- ecological assessment
- range condition

Maps are compiled using a geographic information system and output through a map publishing system at scales of 1:100,000 and 1:250,000

#### **APPLICATIONS**

Traditionally the reports have been used within the pastoral industry to enhance property and stock management. Often, for the first time, the true spatial relationship between legal, topographic and lease infrastructure is shown with any degree of accuracy. This then allows the pastoralist to model changes, and using tailored computer software, the effect of such changes can be predicted. Theoretically it should be possible to optimise the management of the property using all the available biophysical data - however in the present climate the economic benefit of such an exercise may be arguable.

Certainly the data have found general acceptance in regional planning processes and particularly in the identification of areas which may be useful additions to the conservation reserve system. Similarly, valuable information has been provided for the preparation of guidelines for the mining industry in relation to the appropriate siting of facilities and exploration grid lines.

Each survey has significantly added to our knowledge and understanding of the physical resources of the state. However the main limiting factor on their wider usage has been the concentration on pastoralism. This is about to be rectified.

## **FUTURE DIRECTIONS**

Originally the concept for the rangeland survey series was to provide a management tool for the pastoral industry. It was to be a once only inventory of the country which would form the basis of future rehabilitation and monitoring programmes.

Now with the restraints on funding being universally applied throughout government, we are embarking on an expansion programme which could see the participation of multi-agencies in an effort to provide a report which would be useful to a more diverse audience.

To this end we have effectively abandoned the notion of sole emphasis on the pastoral industry, but without compromising existing support. It is our intention to invite other agencies to make use of the existing infrastructure, to enhance their own limited resources and thus enable them to parallel their own research with ours. We perceive significant advantages can be realised in terms of operational costs and time by combining the resources of both government and non-government agencies. This of course may mean the difference between legitimate environmental field studies continuing at a time when there is increasing pressure on resource development and competing land uses but limited funds.

## MONITORING THE MITCHELL GRASS COMMUNITIES OF THE BARKLY TABLELANDS, NT

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#### INTRODUCTION

This report provides a summary of the work on the Barkly Tablelands by the Conservation Commission of the Northern Territory Wildlife Division. The aims of the program are to:

- improve our understanding of the Barkly Tableland ecosystems,
- \* contribute ecological information for the management of the Connells Lagoon Conservation Reserve by the CCNT,
- \* demonstrate the conservation value of the Reserve,
- \* improve our understanding of the role of fire and its effects on the variety of communities of the region, and
- \* demonstrate the value of the Reserve as a reference area for the pastoral industry, which is the dominant land use of the region.

The primary methodology of the work is a longterm pasture monitoring program centred on Connells Lagoon Conservation Reserve with the cooperation of the surrounding pastoral properties. This report describes improved methods for data collection and an account of the first 4 years of data analysis.

Other components of our work on the Barkly Tableland include:

- bluebush transects in the ephemeral wetland ecosystems of Lake Sylvester,
- \* fire management activities in the Mitchell grass communities of Connells Lagoon Conservation Reserve.
- \* satellite image processing to extrapolate our pasture monitoring information across a broader region of the Barklys, and
- \* plans for an expanded program linked with other CCNT activities including both wildlife and land resource surveys.

## **METHODS**

The pasture monitoring program is based on the Dry Weight Rank (DWR) technique (Bastin, 1989). Our initial site selection in 1990 chose paired grazed and ungrazed sites for 3 distinct communities of the region which are represented within Connells Lagoon Conservation Reserve. The three communities are:

- 1. Astrebla grasslands on heavy black soil,
- 2. Astrebla / Mixed grasslands within Coolibah / Gutterpercha woodlands associated with drainage lines, and
- 3. Mixed grasslands on gravelly rise areas with gilgai depressions.

Annual assessments have been at the end of the summer growing season. The timing of the assessment minimised the grazing impact on the seasonal response and preceded the drying off and disintegration of many of the ephemeral plants. The ephemerals are an important component of the species diversity and food sources of the black soil ecosystem.

Data were collected using an HP95LX Palmtop computer. It is DOS compatible and can run compiled programs. Significant modifications were made to the DWR program to take advantage of the improved computing power and to meet our information needs in terms of both conservation and pasture production. The modifications include:

- \* saving the data after each quadrat to prevent untimely loss of data;
- saving both the raw data and the summary data in formats for post-processing by a dBASE program. The raw data are required to correct or update the plant taxonomy or to group species together for analysis;

- \* recording descriptive information for each quadrat. The quadrat parameters include evidence of fire or grazing and position in the landscape. This allows the raw data to be stratified for improved analysis;
- \* saving DECODA sample variable files (for site and quadrat files). Each file is created from a site questionnaire that replaces the site assessment sheet, and
- \* incorporating cover class assessments for species by quadrat. The cover data will provide a better link between our field data and remote sensing data. This method was trialed in April 1994.

Post processing of the data uses a dBASE program to prepare site summary sheets for distribution to our supporting pastoralists, and to create a DECODA community data input file. DECODA is used for preliminary data analysis and data reformatting for multivariate analysis with other statistical packages.

#### **RESULTS**

Seasonal variation has dominated the data. The rainfall pattern alternated between dry in 1990 and 1992 and wet for 1991 and 1993. The two dry years had low species numbers and low biomass while the two wet years had a high number of species and large annual component in the biomass on each site. Our initial analyses have shown encouraging results: our paired sites clustered together indicating good site selection for uniformity of species composition and seasonal response. The initial separation of sites was by each major community rather than by grazed versus ungrazed within communities. The results of further analysis will be presented at the Conference including the weighted average ordination method presented by G. Campbell (1992) at the ARS Conference in Cobar.

#### **DISCUSSION**

Our main progress to date has been the establishment of a longterm monitoring program in the eastern Barklys. It has improved our understanding of the plant taxonomy and the dynamics of the ecosystems in the region. We are using that knowledge for our management responsibilities at Connells Lagoon Conservation Reserve. Cooperation with our neighbouring pastoralists has been very good and has included requests for information feedback and support for establishing additional monitoring sites. Our data will also make a major contribution to the CCNT's monitoring responsibilities associated with the new NT Pastoral Lands Act and our techniques of data collection and processing will simplify and improve the data analysis stage of monitoring.

A second component of the program is a series of fixed transects through northern bluebush (*Chenopodium auricomum*) communities at our 1 km² exclosure on the shore of ephemeral Lake Sylvester. The transects were established in 1991 to monitor bluebush survival after the first recruitment event since the majority of the population died during the extensive flooding in the mid 1970s.

We have also initiated an active fire management program within Connells Reserve. It has been designed to reduce the risk of wildfires starting in the higher fuel loads of the ungrazed Reserve and spreading onto the neighbouring pastoral properties. It also provides the opportunity to study the effect of fire in the Mitchell grass ecosystem in the presence and absence of grazing.

Our plans are to expand our program to cover a greater area of the Barkly region, with the possible establishment of sites at Junction Conservation Reserve in the western Barkly region. We will process a historical sequence of satellite images to follow the seasonal patterns through time and extrapolate our point-based pasture monitoring across the region. We have also developed a GIS database for the region which includes pastoral infrastructure and vegetation community to be incorporated with the remotely sensed data. Our work will also be linked to a regional fauna survey and several land resource surveys of pastoral properties.

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## VARIATION AMONG MONITORING SITES WITHIN MANAGEMENT UNITS - OCCURRENCE AND IMPLICATIONS

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#### **ABSTRACT**

Using species frequency data from two pasture types in a single management unit, variation in range condition trend among 24 monitoring sites (plus 3 ungrazed benchmarks) was assessed over a 7 year period. Variation in indicated trend was recorded among sites on each pasture type at various periods, creating difficulties in interpreting the appropriateness of management. Implications for managers and legislators, particularly the importance of differential utilisation, are discussed.

## INTRODUCTION

Monitoring sites supposedly reflect range condition and trend within much larger units (Wilson *et al.* 1984). Their response to management is extrapolated to the area they are thought to represent and any necessary management changes made accordingly.

However, site representativeness is often debated because, in the extensive pastoral operations of Northern Australia, sites are small in relation to the area they represent. Additionally, management unit heterogeneity is such that utilisation is generally patchy (Pickup and Chewings, 1988). Since wide-ranging management decisions are often based on such monitoring sites, non-representativeness could create significant problems.

#### **METHODS**

Twenty-four permanently-located monitoring sites (plus 3 ungrazed benchmarks) were established in a single management unit at Ord River Regeneration Reserve in 1980. Sites were either black soil plain (BSP) either with (2 sites) or without an overstorey of *Lysiphyllum cumminghamii*, or arid short grass (ASG). Species frequency was recorded on 16 occasions from 100 quadrats (0.5m²) per site over the subsequent 7 years. In some years, data from some or all sites were not collected due to either inaccessibility or fire. The paddock was stocked over the period with between 800 and 1050 cattle (adults plus followers), grazed year round.

BSP and ASG sites were clustered separately and dendrograms produced at the 90% level using the Genstat program. BSP sites were clustered on recorded frequency of *Aristida latifolia* (undesirable), and the desirable species *Astrebla pectinata*, *Astrebla elymoides*, *Chrysopogon fallax*, *Dichanthium fecundum*, *Iseilema vaginiflorum* and *Panicum decompositum*. ASG sites were grouped, using *Aristida contorta* (undesirable), and the desirable species *Aerva javanica*, *Chrysopogon fallax* and *Enneapogon polyphyllus*.

Frequency data were analysed for 3 dates (early dry season 1981, 1983 and 1986), likely monitoring program intervals. Range condition trend was assessed from the desirability or not of the recorded species.

## **RESULTS**

Site clusters, which generally implied similar proportions of species, indicated initial differences among both BSP and ASG sites and changes over the sampling period. Additionally, similarity of sites within the various hierarchical structures changed when depicted graphically. Outliers that did not cluster with other sites suggested atypical frequency values for one or more species. There was a tendency for BSP benchmark sites to cluster together or to be in adjacent clusters. Sites clustered with benchmark sites in Year 1 tended to continue in the same cluster or in an adjacent cluster over the sampling period, but there were constant changes. Only some changes could be readily explained by an atypical frequency figure for one or more species, which, although by no means certain, could be accounted for by operator error.

ASG site variation over time, either with or separate from the benchmark, could generally be explained by one anomalous frequency value. But again some changes suggested different response to management among sites.

Between 1981 and 1983, 4 BSP sites (including one benchmark site) exhibited upward trend, 4 remained unchanged and 9 (including the other benchmark) deteriorated. From 1983 to 1986, 10 BSP sites exhibited negative trend (including both benchmarks) and 6 improved. For the entire period (1981 to 1986), 4 sites improved and the remainder (including both benchmark sites and 2 of the other 3 sites that had previously improved) declined in condition.

For ASG sites, from 1981 to 1983, 7 sites improved, and 3 (including the benchmark) deteriorated. From 1983 to 1986 all ASG sites exhibited an improving trend, although the magnitude of the change varied widely. Figures for the entire 1981 to 1986 period were similar to the 1981 to 1983 period, although the sites improving during this period differed from those that had previously improved. Two sites exhibited almost no change.

#### DISCUSSION

Although providing a key for interpreting vegetational response across a series of essentially likemanaged plots, classification alone does not indicate whether the vegetation on monitoring sites consists of distinct or overlapping communities, nor if temporal changes suggest a similar trend (Pielou, 1969). Additionally, many changes in species frequency were non-significant, or could, because of their magnitude, perhaps be ascribed to species mis-identification or other operator error.

However, response to management undoubtedly differed among sites depending on what monitoring site (or group of sites) was considered. Initial clustering identified quite distinct differences in antecedent condition. Over time, some sites improved in condition, others declined, and the response of any one site was often temporally inconsistent. This implies that the dynamics of within-paddock grazing were sufficient to cause a degree of differential plant response. While not unexpected, this result, given differences in antecedent condition and noted preference for certain areas (and therefore sites) by cattle, highlights that site location is vitally important in monitoring and in the ability to extrapolate results. Therefore, "recipe-type" guidelines could cause problems. Sites must be located after full consideration of the grazing dynamics of the area and full account is taken of the grazing patterns that exist within a paddock or management unit. This demands a far greater examination of the paddock, including an understanding of what occurs away from tracks and fencelines, than that which may be currently accepted.

## **ACKNOWLEDGMENTS**

Assistance provided by the many Department of Agriculture staff who collected data during this trial is acknowledged.

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#### THE VEGETATION OF CURRAWINYA NATIONAL PARK

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#### **ABSTRACT**

As part of a study into vegetation change following the destocking of Currawinya National Park, Dawson and Boyland's (1974) land system classification was evaluated. The results show their classification to be robust and indicates an increase in woody weeds and a decrease in grass species over a twenty year period.

#### INTRODUCTION

In 1992 a system to monitor changes in vegetation on Currawinya National Park following destocking was developed. Dawson and Boyland's (1974) land system map was utilised and understanding the robustness of this classification became vital in determining representativeness of the monitoring sites.

#### **METHODOLOGY**

A gradsect sampling approach was used to sample the 9 major land systems identified on the Park. 120 sites, each 500m<sup>2</sup>, were sampled and a range of environmental and floristic variables were measured and recorded.

The data were stored and analysed using the ecological data storage and analysis package DECODA and the floristic classification of the data was undertaken using TWINSPAN (Hill 1979).

#### **RESULTS**

Our classification identified 12 vegetation units. These were compared with the land systems of Dawson and Boyland (1974). Some land systems contained one vegetation unit while others contained up to five. Dawson and Boyland (1974) described land units for each land system. A comparison of this survey's vegetation units with Dawson and Boyland's land units showed that their descriptions frequently corresponded with ours. The exceptions to this are in Table 1.

Table 1. The percentage of each vegetation unit that is inconsistent with Dawson and Boyland's (1974) descriptions.

Vegetation Unit	% Inconsistent
Tall shrubland	5%
Mulga / Eremophila gilesii	25%
Mulga / Eremophila bowmannii	100%
Soft Mulga	12%
Bluebush shrubland	17%
Canegrass claypan	17%
Open herbfield	29%

#### **DISCUSSION**

Dawson and Boyland's (1974) survey was mapped at a scale of 1:500,000 while this study selected areas of 100m<sup>2</sup>. No doubt scale alone could account for some inconsistencies. Another hypothesis for the inconsistencies is that the vegetation has changed since Dawson and Boyland surveyed in 1971. Dawson and Boyland (1974) do not describe areas with a defined shrub understorey in the soft mulga land systems whereas we identified sites with these characteristics. Many authors have discussed the increase of woody shrubs in the mulga lands (e.g. Harrington, 1986), and Dawson and

Boyland (1974) predicted that both *Eremophila gilesii* and *Eremophila bowmannii* would increase in density. We believe these prediction are vindicated by the results. In 1974, Dawson and Boyland identified these woody weeds in the sandplain mulga land systems. Our data suggest that they have moved to invade soft mulga land systems. This explains some of the inconsistencies identified between the two classifications.

Graminoid species in our samples were usually infrequent where Dawson and Boyland's (1974) descriptions listed many species of Graminoids that were frequent. For example, this study recorded three graminoid species in the soft mulga vegetation unit and only one of these was frequent. Dawson and Boyland's (1974) descriptions listed eight frequent graminoid species in the same type of land unit.

## CONCLUSION

The results of the study support the use of Dawson and Boyland's (1974) classifications. Inconsistencies can be attributed to the scale of the land system map and changes in composition over time.

The existing models of composition change for the mulga lands (e.g. Friedel 1991, Pressland 1984) are consistent with the changes identified by this study. This increase in woody weeds and a decrease in the grass species are also consistent with an analysis of the aerial photographs which showed an increase in woody shrub cover occurring in the 1970's (Witt 1993). Although the loss of grass species is evident, this may be partly attributed to seasonal conditions as the early 1970's was marked by good rainfall while the area is currently in drought status. Continuing work will clarify this matter.

#### **ACKNOWLEDGMENTS**

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## **WOODY WEEDS 10 YEARS LATER**

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## **ABSTRACT**

Long-term monitoring sites were established to quantify changes in the number and size of the main woody weed species of concern to landholders in central western Queensland. Populations of gidgee (Acacia cambagei), mimosa (A. farnesiana) and prickly acacia (A. nilotica) have been measured to examine their dynamics. Over a 10 year period there has been no significant recruitment of these species despite a 2 year interval when rainfall was above average Existing plants have increased in size. We conclude that 10 years is but a brief period in the life cycle of these species.

## INTRODUCTION

Long-term monitoring sites have been installed in central western Queensland since 1983 to provide an objective record of changes that are occurring in the main woody weed species. These records are important because of the turnover of personnel both on properties and within government organisations.

The species of greatest concern to landholders is the native gidgee (*Acacia cambagei*) which creates difficulties either through the spread of seedlings (gidgee invasion) or as regrowth after clearing (gidgee regrowth). Other species included in this report are the introduced prickly acacia (*Acacia nilotica*) and the cosmopolitan mimosa (*Acacia farnesiana*).

#### **METHODS**

Belt transects 4 m wide and 500 m long were established at each site according to procedures described by Carter *et al.* (1987). These sites, which were selected within commercially grazed paddocks, were last read in 1992. At each recording canopy height and diameters were measured to the nearest 0.05 m.

## **RESULTS**

Seasonal conditions during the period covered by these observations, 1983 to 1992, were characterised by below average summer rains (in 7 out of the 10 years) and above average winter rains (in 5 out of 10 years). Changes in the number of woody plants and their canopy cover at eight sites appear in Table 1. Apart from the mimosa sites where a small increase was recorded, plant numbers declined over the period while at all sites canopy cover increased.

Table 1. Percentage changes in plant numbers and canopy cover at eight sites

Stort recor	Percentage o	_	
Start year	Plant numbers	Canopy cover	
1983	-31	+122	
1983	-3	+39	
1984	0	+36	
1987	+2	+136	
1984	+2	+37	
1986	+7	+66	
1986	0	+55	
1987	-24	+252	
	1983 1984 1987 1984 1986	Plant numbers  1983 -31 1983 -3 1984 0 1987 +2 1984 +2 1986 +7 1986 0	Plant numbers   Canopy cover     1983   -31   +122     1983   -3   +39       1984   0   +36     1987   +2   +136       1984   +2   +37   1986   +7   +66     1986   0   +55

#### **DISCUSSION**

The Taranaway site was established after above average winter rain when 72% of the gidgee plants present were seedlings < 0.5 m high. Poor summer rains in the following 2 years resulted in many of these seedlings disappearing (dying) and these losses accounted largely for the 31% decline in plant numbers. There were few gidgee seedlings at the Pemberley site where plant numbers have been relatively static. At both sites canopy cover increased with the most rapid changes occurring between 1989 and 1991 when rainfall was above average.

Significant recruitment of gidgee has not occurred at either of these invasion sites. Seasonal conditions favoured widespread seed production by adult gidgee trees in the spring of 1991 but subsequent rainfall, which produced abundant germination, did not support their establishment. Gidgee seed displays no dormancy and seed loads do not accumulate in the soil because germination is readily triggered by rain (Reynolds *et al.* 1992). These features of gidgee seed indicate that large scale recruitment is confined to consecutive years of above average rainfall - in the first year flowering and seed set take place; once seed is on the ground a sequence of favourable rains are required to effect recruitment.

At the gidgee regrowth sites, which were both chained 2 years before observations started, plant numbers changed little. The larger increase in canopy cover at Albilbah reflects the denser stands of gidgee at this site compared to the Blendon site.

The mimosa sites were selected within areas that had a conspicuous population of mimosa relative to nearby open downs country. The small net increase in plant numbers at both sites supports the view that mimosa expands slowly and is not strongly invasive. At the Northampton site plant numbers increased by 26% between recordings in 1986 and 1989 but most of these seedlings were gone 20 months later.

The site at Rangelands was located on a relatively flat mid-slope with scattered prickly acacia to examine the rate and extent of its encroachment. Over the 6 years of observation there has been no change in the numbers of adult plants. In 1990 there was a flush of prickly acacia seedlings but they all died in the following 18 months.

When the site at Politic was installed 61% of the prickly acacia plants were seedlings < 0.5 m high. In the following year, when rainfall was grossly deficient (< decile 2), 40% of these seedlings died and this mortality explains the overall decline during the observation period. The large increase in canopy cover at this site reflects its high density of prickly acacia.

Despite above average rainfall from autumn 1989 to autumn 1991, no large increase in the number of prickly acacia plants has been detected. The abnormally high winter rains of 1989 and 1990 produced abundant seed on adult trees, yet subsequent conditions did not favour recruitment.

We conclude that seasonal conditions between 1983 and 1992 in central western Queensland did not produce major recruitment of gidgee, mimosa or prickly acacia. However, canopy cover and therefore competition between these woody species and their herbaceous understoreys, have increased markedly.

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## RANGELAND MONITORING IN THE NORTHERN TERRITORY LESSEE PARTICIPATION A KEY INGREDIENT

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Under the Northern Territory Pastoral Land Act 1992, the Minister, the Pastoral Land Board and pastoral lessees all have responsibilities to ensure land held under pastoral lease is used in accordance with sustainable land use principles.

#### THE OBJECTIVES OF THE PASTORAL LAND ACT ARE:-

- (a) to provide a form of tenure of Crown land that facilitates the sustainable use of land for pastoral purposes and the economic viability of the pastoral industry;
- (b) to provide for:
  - the monitoring of pastoral land so as to detect and assess any change in its condition;
  - the prevention or minimisation of degradation or other damage to the land and its indigenous plant and animal life; and
  - the rehabilitation of the land in cases of degradation or of other damage;
- (c) to recognise the right of Aborigines to follow traditional pursuits on pastoral land;
- (d) to provide reasonable access for the public across pastoral land to waters and places of public interest; and
- (e) to provide a procedure to establish Aboriginal community living areas on pastoral land.

#### GENERAL DUTY OF PASTORAL LESSEES. Duties of a lessee under the Pastoral Land Act are -

- (a) to carry out the pastoral enterprise under the lease so as to prevent degradation of the land;
- (b) to participate to a reasonable extent in the monitoring of the environmental and sustained productive health of the land; and
- (c) within the limits of the lessee's financial resources and available technical knowledge, to improve the condition of the land.

## **CONDITIONS RELATING TO LAND MANAGEMENT.** The Pastoral Land Act provides that the lessee will -

- (a) take all reasonable measures to conserve and protect features of environmental, cultural, heritage or ecological significance;
- (b) allow the establishment on the leased land of monitoring sites as required by the Board and allow reasonable access to those sites for the purposes of this Act;
- (c) allow fencing of reference areas declared under section 74(1) and access to those areas and fences for maintenance purposes; and
- (d) maintain in good repair all improvements necessary for sustainable pastoral production on the land.

## PASTORAL LAND BOARD ADVISORY COMMITTEE

A Pastoral Land Board Advisory Committee comprising senior executive and professional representatives from the Departments of Lands, Housing and Local Government, Primary Industry and Fisheries and the Conservation Commission has been established to assist the Pastoral Land Board develop and establish rangeland monitoring systems.

## THE RANGELAND MONITORING FRAMEWORK IN THE NORTHERN TERRITORY

The Pastoral Land Board in consultation with CSIRO, Government land management agencies (Pastoral Land Board Advisory Committee) and the pastoral industry has developed a two tiered monitoring system for the Northern Territory.

**Tier One** - is a photopoint based system with pastoralist participation at the property level. It is designed to increase knowledge and awareness of plant and pasture behaviour and assist lessees

with management decisions by providing a means of documenting changes at specific pasture sites over time.

These sites, known as **monitoring sites**, are installed by officers of the Department of Lands, Housing & Local Government in collaboration with lessees. These sites are to be revisited every 2-3 years. Monitoring files are created in duplicate and are being kept by the pastoralist and the Pastoral Land Board.

Lessees are encouraged to visit the sites every 12 months and complete the site data sheets. Progress and methodology are kept under constant review to ensure consistency and continuity under the program.

**Tier Two** - involves monitoring by Government agencies at a regional level using a smaller number of sites which, wherever possible, will include a cross section of the Tier One monitoring sites.

At these sites, which will be known as **reference sites**, objective, detailed scientific information on range condition will be gathered by the Conservation Commission using conventional scientific methods. Techniques to use remote sensing satellite data are being developed to augment this information providing an information base for interpreting the reasons for any change detected at either Tier One or Tier Two levels.

This information can be used by rangeland officers and lessees in interpreting reasons for change and guiding management decisions.

## IMPLEMENTATION OF PROGRAMME

In early 1993 the Pastoral Land Board decided that pastoral land monitoring would begin as a pilot program in the Victoria River region of the Katherine pastoral district in accordance with a framework and methodology developed by the Board in consultation with the industry.

Training courses have been run to provide the Pastoral Officers of the Department of Lands, Housing & Local Government with the additional necessary skills.

400 Tier One monitoring sites were established on 39 leases in the Victorian River region during May, June and July 1993. The Board reviewed progress by visiting lessees and monitoring sites during October 1993. It was most satisfied with the cooperation and participation of lessees with the Pastoral Officers in selecting and establishing sites.

In August 1993 the Board decided Tier One sites should be extended into the Elsey, Roper and Gulf regions of the Katherine pastoral district. A further 125 monitoring sites were established on 23 leases prior to the onset of early rains and storms.

In December 1993 the Board decided the establishment of Tier One monitoring sites should be extended into the Barkly and Alice Springs pastoral districts in 1994 depending on seasonal conditions. By March 1994, 140 monitoring sites had been established on 16 leases in the Alice Springs region prior to establishment of sites in the Barkly Tablelands during the 1994 dry season.

The Acting Chairman of the Northern Territory Pastoral Land Board, David Wilcox, expressed his appreciation of the considerable effort of Department of Lands, Housing & Local Government officers in terms of initiative and ingenuity in successfully implementing this program in the field which he says is evidenced by the high degree of industry acceptance.

## PLANT AND ANIMAL PESTS

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#### KANGAROO HARVESTING ON PASTORAL PROPERTIES

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#### **ABSTRACT**

Kangaroo harvesting impacts on the rangeland, livestock and financial components of property management. A grazier's decision on an appropriate level of kangaroo harvesting will relate largely to economics. However, traditional views and prejudices as well as considerations on grazing management and rangeland condition may also be important. The price paid for kangaroos would need to rise substantially before graziers could benefit sufficiently to consider a major move to harvesting.

## KANGAROO HARVESTING AND PROPERTY MANAGEMENT

Kangaroo management may involve:

- (i) opportunity harvesting;
- (ii) attracting increased numbers by forage manipulation; and
- (iii) permanently reducing stocking rate.

In some situations reducing the livestock component of total grazing pressure may result in improvement of rangeland condition.

It is generally recognised that large numbers of kangaroos add significantly to the total grazing pressure. In addition, livestock grazing pressure can be largely controlled within a paddock whereas kangaroo grazing pressure cannot be controlled.

A comparative profitability assessment of livestock production and kangaroo harvesting must take into account the competition for resources and the total cost imposed by each one on the other.

Where a grazier develops a self-harvesting kangaroo enterprise, financial management and time resources will be reduced for livestock production. The fact that kangaroos are already causing a loss to the livestock enterprise must act as an incentive for a grazier to develop some level of harvesting kangaroos. Nonetheless, a move to attract kangaroos or reduce livestock numbers would increase the level of competition for both natural and management resources.

Gross margins for kangaroo harvesting and livestock production are shown in Table 1. The figures indicate that harvesting of kangaroos for pet food or hides is less profitable than livestock production, but kangaroo harvesting for human consumption is more profitable than livestock production. However, the differences are not large and gross margins on individual properties will vary significantly.

Table 1. Comparison of Gross Margins for Kangaroos and Livestock.

	Production Enterprise						
Conne Mangin		Kangaro	os	Sheep	Cattle		
Gross Margin	Pet Food	Hide	Human Consumpt.				
\$/DSE (1) \$/ha (2)	6.35 1.60	4.95 1.25	9.80 2.45	7.60 1.90	9.85 2.45		

- (1) Assuming 1 DSE = 1.4 kangaroos; (e.g. Mitchell grass or open mulga)
- (2) Assuming safe carrying capacity of 4 ha/DSE

## KANGAROO HARVESTING OPERATIONS

On most properties graziers would benefit most by concentrating on livestock production and contracting a professional shooter. Added to this is the aversion by some graziers to be game meat producers (which requires mainly harvesting skills) rather than domestic meat and fibre producers (which requires a wider range of skills and resources).

The mobility of kangaroos means that it is difficult to relate input (pasture) directly to output for any one property. Consequently, it is proposed that harvesting should include a cooperative arrangement between neighbouring properties involving:

- (i) a professional shooter under a contract;
- (ii) kangaroo carrying capacity for each property as a basis for proportional allocation of returns to individual pastoralists.

Returns from kangaroos would have to be significantly higher than current values before it would be worthwhile for a professional shooter to include a significant payment to the grazier and be consistently higher than for livestock returns before most graziers would consider moving into more than opportunity harvesting management.

#### AUSTRALIAN SHEEP BLOWFLIES BREED IN GOAT CARCASSES?

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# **ABSTRACT**

No Australian sheep blowflies (*Lucilia cuprina*) developed on goat carcasses exposed monthly for a year near Carnarvon, WA. Competition and predation from native *Chrysomya* species was largely responsible.

# INTRODUCTION

Feral goats are found over much of the semi-arid and arid pastoral areas of WA. A feral goat eradication campaign begun in 1991 in the southern pastoral areas of WA resulted in over 180,000 feral goats being shot and left to rot in the field. Animal carcasses provide a breeding ground for many species of blowfly, hence pastoralists became concerned that the carcasses were providing breeding sites for the sheep blowfly, *L. cuprina*. The aim of this study was to determine if goat carcasses enable *L. cuprina* to successfully develop from egg to adult.

#### **METHODS**

Every month for a year, 4 sheep and 4 goat carcasses (shot on site) were placed at Boolathana Station, 50km N of Carnarvon, WA. At the time of carcass placement, wind-oriented traps at 5 sites monitored the fly population on Boolathana. All carcasses were undisturbed for 10-14 days after which a sample of pupae (soil) and maggots (on carcass) were taken. These developed into adult flies in cages for species identification.

### **RESULTS**

Table 1. The number and species of fly trapped at Boolathana each month.

Year	Month	L. cup.	Ch. ruf.	Ch. var.	C. dubia	M. vet.
1992	Sept	16	13	2	14	10
	Oct	123	240	29	10	29
	Nov	0	12	1	0	8
	Dec	2	39	1	0	13
1993	Jan	0	8	· <b>O</b>	0	23
	Feb	0	40	0	0	98
	March	0	5	0	0	159
	April	0	62	3	2	32
	May	0	4	0	28	9
	June	0	0	0	0	0
	July	0	2	45	189	5
	Aug	1	37	61	39	14
	Sept	<b>2</b>	1	0	6	6

Species were - Chrysomya rufifacies, Chrysomya varipes, Calliphora dubia, Musca vetustissima and Hydrotaea rostrata.

L. cuprina was only trapped from Sept to Dec, whereas native Chrysomya were present all year (Table 1). Predominantly Chrysomya species developed on the carcasses, whereas only a single L. cuprina adult developed (Table 2).

Table 2. The number and species of flies developing on goat carcasses.

Year	Month	L. cup.	Ch. ruf.	Ch. var.	H. rost.	M. vet.
1992	Sept.	0	>1,500	>1,000	0	0
	Oct	0	>1,000	>1,500	0	30
	Nov	0	>2,000	>2,000	0	0
	Dec	0	>650	>100	0	0
1993	Jan	0	135	92	0	150
	Feb	1	>1,000	>500	0	>500
	March	0	>1,000	. >800	0	>1,000
	April	0	>1,600	>1,600	0	11
	May	0	>2,000	>1,800	474	157
	July	0	>2,000	>2,000	450	0
	Aug	0	>2,000	>1,500	>1,000	0
	Sept	0	>2,000	>2,000	0	0
	Oct	0	>2,000	>2,000	0	0

#### **DISCUSSION**

Exposure of goat carcasses each month for a year near Carnarvon, WA showed that *L. cuprina* were incapable of developing into adults on these carcasses. Native *Chrysomya* species (*rufifacies* and *varipes*) were the most dominant species developing on goat carcasses every month. *Chrysomya* larvae are predatory on larvae of *L. cuprina* and *Calliphora* spp. Although *L. cuprina* lays eggs on animal carcasses, the *Chrysomya* larvae prevent *L. cuprina* from developing to adults through predation and competition for food.

Fly traps only caught *L. cuprina* adults from August to December, whereas *Chrysomya* were present in all months except June. Flystrike was detected on sheep mustered on Boolathana in Aug/Sept 1993. Rainfall during the study was 115mm, which was well below the 237mm annual average. This may account for the low numbers of flies trapped over the year.

*Ch. rufifacies* is hard to distinguish from *L. cuprina* with the naked eye, hence pastoralists can easily mis-identify flies and assume that large numbers of green blowflies on goat carcasses represent large numbers of sheep blowflies. The findings of this study are reassuring to the pastoralist, as the slaughter of feral goats will apparently not result in an increase in sheep blowfly numbers.

# **ACKNOWLEDGMENTS**

Thanks to all the staff at Gascoyne Research Station who helped with the onerous task of setting out the carcasses and collecting the maggots/pupae.

# INVASIVE SHRUBS IN THE TROPICAL WOODLANDS: SEED AND SEEDLING ECOLOGY IN THE DEVELOPMENT OF CONTROL STRATEGIES

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# **ABSTRACT**

Strategies for managing exotic problem shrubs in the tropical woodlands will involve establishing general principles in relation to such invasions and tailoring them to the varying ecology of the different shrub species.

# INTRODUCTION

In the tropical woodlands of northern Australia exotic shrubs are major weeds. *Cryptostegia grandiflora* (rubbervine) and *Ziziphus mauritiana* (chinee apple) were deliberately introduced in the 1860-70s. *Cryptostegia* was widely planted as an ornamental in northern and coastal Queensland. *Ziziphus* was grown as an ornamental and for its fruit, particularly around mining towns in north Queensland. *Cryptostegia* is distributed across 20% of Queensland, including 700,000 hectares of heavily infested country (Humphries *et al.* 1991) and *Ziziphus* is spread over more than 150,000 hectares, mainly in Queensland but also in the Northern Territory and Western Australia (Anderson 1993).

'Woody weed' problems in the southern rangelands have largely involved native species with relatively stable ranges. In contrast, *Cryptostegia* and *Ziziphus* have much potential for further range expansion as well as increasing in density within their current ranges. Control strategies for these species must encompass the related processes of population increase within an existing range and range expansion, so the ecology of seed and seedling stages is of primary interest.

### SEED AND SEEDLING ECOLOGY

Cryptostegia and Ziziphus differ in reproductive and dispersal ecology and this affects rates and patterns of their invasions, and hence control strategies. Cryptostegia grows either as a shrub or a vine capable of climbing 30-40 metres into the canopy of large trees. Seeds released from these heights can move some distance given their adaptations for wind dispersal. Even small shrubs (<3m high) can produce over 30 pods in one season containing, on average, about 300 seeds per pod. Some seeds may be produced within three years of germination or once plants are over 1m high (Fig. 1). Laboratory tests suggest that most seed will germinate rapidly whenever moisture levels are adequate. Over 90% of freshly harvested seed germinated within 10 days of wetting at 20° and 25°C. After storage on the soil surface for 6 months, equivalent values were 85% (3 x 100 seeds per test).

The fruit of *Ziziphus* has typical endozoochorous characteristics: a fleshy mesocarp and a protective endocarp. Each fruit encloses a single (sometimes two) seeds. The intact endocarps, and the seeds within, can be found in dung of cattle, feral pigs and macropod marsupials, though we have no data on the amounts of seed actually transported. Cattle have the potential to introduce large numbers of viable seeds to a site (paddock) and pigs may also move seeds over long distances. Emus could play a role similar to pigs. Other birds may also be dispersal agents though many species probably consume flesh from the fruits rather than ingest them. Black cockatoos appear to destroy large numbers of seeds rather than act as dispersal agents; seeds had been removed from over 70% of fruits collected from beneath ten large trees. Many seedlings emerge beneath adult plants (Fig. 2).

In a single season, the number of fruits produced by ten large trees ranged from 83-12,500 per tree. Plants over 1m high can produce seed though the time from germination to first seed production is unknown (Fig. 1). Seed dormancy is apparently enforced by the endocarp. When seed was removed from the endocarp, 56% germinated when placed in moist sand in a glasshouse. The equivalent value for seed retained within the endocarp was only 3.3% (3 x 50 seeds per treatment). Even under continuous moisture, germination of *Ziziphus* can be spread out over several months at least.

#### IMPLICATIONS FOR RESEARCH AND MANAGEMENT

*Cryptostegia* dispersal is unaffected by management and individuals may establish some distance from parent plants. A control strategy should aim to reduce seed production (e.g. by burning), identify the landscape positions most prone to colonisation, and detect and kill isolated plants and populations. Persistent seed banks may not be a problem.

The current distribution of *Ziziphus* consists of many relatively isolated sub-populations. Management can probably have a major impact on dispersal, *viz.* by appropriate control of cattle movements, and so reduce the probability of new sub-populations establishing. A means of dealing with a persistent seed bank may be required in a control strategy for this species.

Cost effective control strategies for exotic shrubs of the tropical rangelands will require a better understanding of the processes of range expansion and plant establishment. This will see the emergence of general principles covering, for example, relationships between woody and herbaceous components, the role of fire and the need for early containment. However, there will also be a need to tailor strategies for individual species, taking into account range and distribution patterns, dispersal mechanisms and temporal patterns of recruitment.

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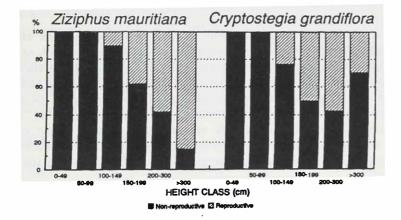


Fig. 1. Proportion of plants of *Ziziphus* and *Cryptostegia* that were reproductive in 1993.

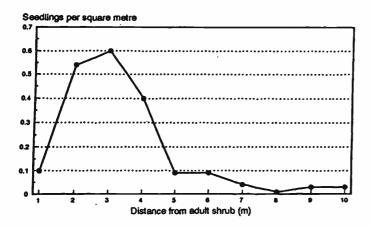


Fig. 2. Density of Ziziphus seedlings in relation to distance from adult plants. Each value is mean of 68 1-squaremetre quadrats.

# COMPARATIVE EMERGENCE OF VULPIA SPECIES UNDER FIELD AND GLASSHOUSE CONDITIONS

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#### **ABSTRACT**

Two species of *Vulpia*, *V. myuros* and *V. bromoides*, are serious weeds of pasture in many parts of eastern, southern and south-western Australia. In glasshouse tests, over 95% of seeds of both species emerged within 14 days of sowing. Seed from the same bulk seedlot as used in glasshouse tests was sown back into established pasture at known rates and emergence recorded every month for two years. Only 21% of the seed bank of *V. myuros* and 46% of the seed bank of *V. bromoides* had emerged in the first seven months and total emergence was found to be staggered over a 16-month period. The sharp contrast between glasshouse and field results may explain why control methods for these annual grasses based on the transient seed bank hypothesis have proved unsuccessful.

#### INTRODUCTION

Vulpia species are cool-season annual grasses which originated in the Mediterranean region. Approximately 30 taxa are recorded in the Northern Hemisphere, of which 6 have become naturalised in various temperate parts of Australia. Most Vulpia species have the capacity for extremely high seed production and their awned seeds are a contaminant of wool and a cause of injury to livestock. Autumn sowings of improved pasture can fail completely in the presence of high populations of Vulpia spp. which, along with several other annual grasses, are also responsible for the carryover of cereal diseases. The plants are short-lived and in the absence of new seed introduction, the only link between successive generations at a given site is the soil seed bank.

# **METHODS**

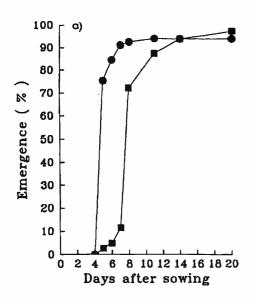
Seed was collected in December 1990 from monospecific stands of *V. myuros* and *V. bromoides* growing at the Newholme Field Laboratory near Armidale, New South Wales. Four replicates of 100 seeds of each species were sown 10 mm deep in 15 cm pots containing a 1:1:1 mixture of sand:peat:vermiculite, in January 1991. Pots were placed in a glasshouse under a regular watering regime and seedling emergence recorded for 20 days.

A further 6,000 seeds were hand-sown 5 mm deep into knife-cuts made into the root-zone of established pasture within three replicated  $25 \times 25$  m fenced areas at the Newholme Field Laboratory. These areas had been sprayed with herbicide in October 1990 to prevent seed-set of the existing *Vulpia* populations. Two hundred seeds of each *Vulpia* species were individually placed in each of  $30 \times 1$  m rows within these pre-treated areas in February 1991 and emerged seedlings were recorded and removed every month for two years.

### **RESULTS**

Vulpia myuros was the faster germinating of the two species in the glasshouse experiment, taking 5 days to reach 50% emergence compared with 8 days for V. bromoides (Fig. 1a). In previous glasshouse experiments undertaken in 1990, a range of accessions of V. myuros collected from the Northern Tablelands of NSW were all found to be faster germinating than a range of V. bromoides accessions. However, no significant difference had been found in their cumulative emergence percentages and that was again evident in this study, with 95.5% V. myuros and 98.8% V. bromoides successfully establishing under glasshouse conditions (Fig. 1a).

This contrasts sharply with the data obtained in the field trial, in which the cumulative emergence percentages of both species in the presence of established pasture were considerably less than in the glasshouse and where twice as many *V. bromoides* (46%) as *V. myuros* (21%) emerged over the first seven months of the experiment (Fig. 1b). In the remaining 17 months, seedlings emerged spasmodically in the period from March to June 1992, amounting to a further 5% of the seed bank of *V. myuros* and 3% of the seed bank of *V. bromoides*.



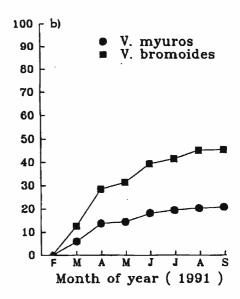


Figure 1. Cumulative emergence percentages of *V. myuros* and *V. bromoides* under (a) glasshouse conditions and (b) field conditions.

# **DISCUSSION**

In a paddock survey undertaken at Newholme Field Laboratory in spring 1990, the percentage composition of the naturalised *Vulpia* population was found to be 30.4% *V. myuros* and 69.6% *V. bromoides*. These relative frequencies were similar to the 37.8% *V. myuros* and 60.8% *V. bromoides* recorded by McIntyre and Whalley (1990) in a random survey of 100 sites on the Northern Tablelands in 1989.

It is interesting therefore, that similar relative emergence figures were again obtained from an artificially established seed bank containing equal number of viable seeds of both species, sown at the same time and subjected to the same environmental conditions. The factors responsible for maintaining Vulpia populations in this ratio are not understood, but the larger seed size of V. bromoides (1000 seed weight is twice that of V. myuros) may contribute to its higher rates of establishment under field conditions. These data highlight the fact that observed field populations do not necessarily reflect the size of the soil seed banks of the component species.

Furthermore, the comparison of field and glasshouse results raises serious doubts about the usefulness of glasshouse data for predicting the behaviour of *Vulpia* spp. under field conditions. The rapid emergence of *Vulpia* species in glasshouse trials and from cultivated field soil may also explain why they have previously been considered to have "transient" seed banks.

The difficulties experienced with the control of *Vulpia* spp. relate to the fact that they form extremely large soil seed banks, a proportion of which can persist for at least three years (Jones *et al.* 1992). Consequently, herbicide treatments such as winter cleaning and spray-topping, unless they form part of a comprehensive pasture management package, can reduce *Vulpia* populations for only one, or at the most, two years, after which infestations return to previous levels by recruitment from the residual seed bank.

# **ACKNOWLEDGEMENTS**

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## RABBIT CONTROL RESEARCH IN ARID PASTORAL LANDS

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# **ABSTRACT**

This poster presents preliminary information from a long-term study of the environmental and economic benefits of rabbit control on a pastoral lease and adjacent National Park in S.A. Warrens must be ripped deep and wide to reduce re-opening rates, and therefore cost of control. Kangaroos have concentrated in rabbit-free areas when sheep were also absent, and sheep grazing has also increased in rabbit-free areas on the pastoral lease, confirming the need for total grazing management of pastures after rabbit control. The recent run of good seasons has resulted in perennial plant recruitment and pasture response over the whole trial area, but the response has been more positive in rabbit-free areas. Soil erosion trends are not yet clear, but it seems scalds may be contracting more in rabbit-free areas.

## INTRODUCTION

Rabbit control research in arid pastoral lands must demonstrate to the pastoral community the advantages and benefits of rabbit control and suggest local strategies. A trial, in the northern Flinders Ranges (SA), is attempting to document the impact of rabbit grazing pressure on perennial plant recruitment, pasture quality and quantity, soil erosion, and use of the pasture by other grazing animals e.g. sheep and kangaroos. In the process of collecting this information, valuable knowledge on the "best practice" for destroying warrens has also been obtained.

#### **METHODS**

The trial site is located on Gum Creek Station and the adjacent Flinders Ranges National Park, in the northern Flinders Ranges. Approximately half the trial area was ripped to create the rabbit-free areas (details in *Range Management Newsletter* 93/3). This allowed comparisons between different treatments i.e. rabbit-grazed and rabbit-free areas on both the park (sheep-free) and pastoral lease (sheep-grazed).

For each 8 treatment blocks, baseline information was collected on:

- \* Number of rabbits and other grazers along a set spotlight transect
- \* Soil erosion, measuring scalds and gullies (6 per block)
- \* Density estimates of grazing animals from dung transects (7)
- Vegetation monitoring sites, using step-point and Jessup transects (3);

Data continues to be collected at 6 and 12 monthly intervals.

Two ripping techniques were compared:

- \* cross-ripping, deep (90 cm) and wide (3 m beyond the visible edge of the warren),
- \* cross-ripping, shallow (45 cm) and to the visible edge of the warren.

# **RESULTS**

# Rabbit control methods

Comparison of the two ripping techniques left no doubt as to the value of good technique. Only 2% of the warrens ripped "deep and wide" had re-opened 6 weeks after ripping, compared to 32% of the "shallow and narrow" ripped warrens. Of the "shallow and narrow" ripped warrens that re-opened, 20% re-opened on the edge of the warren and 17% re-opened in the centre (5% opened at edge and centre), indicating both depth and width of ripping are important for good control. Follow-up fumigation and explosives work has almost completely eradicated rabbits in the treated areas.

# Spotlight transects

Extremely high numbers of kangaroos have moved into the rabbit-free areas in the park, but elsewhere numbers have remained relatively unchanged.

# **Dung transects**

Rabbit dung was by far the most abundant dung type in the trial area before treatment (60% of all dung collected). Removal of rabbits had resulted in increased grazing by both kangaroos and, to a lesser extent, sheep; in rabbit-free areas kangaroo dung increased by 350% and sheep dung by 70%, relative to rabbit grazed areas. Some old rabbit dung remains in the rabbit-free areas.

# Vegetation monitoring

Unseasonal rains over the last two summers have resulted in a flush of plant growth and recruitment of perennial species in both rabbit-grazed and rabbit-free areas. The recruitment of *Acacia victoriae* and *Senecio magnificus* in rabbit-free areas was notably higher than in rabbit-grazed areas. In the absence of rabbits, *A. victoriae* and *S. magnificus* increased by 131% and 33% respectively. In the presence of rabbits, *A. victoriae* increased by only 27% and *S. magnificus* decreased by 51%.

Percentage cover using the step-point technique can provide a coarse indication of changes in pasture quality and quantity. Seasonal conditions have promoted an increase in cover of desirable plants (and a decrease in less desirable components e.g. amount of bare ground) in both rabbit-free and rabbit-grazed areas. These changes are consistently more desirable in the rabbit-free areas, but the differences (at this stage) are only minor.

# Soil erosion monitoring

The rate of erosion (regardless of treatment) is faster than expected with up to 50 cm of soil removed from some gully edges and 10 cm from scald surfaces. Monitoring of erosion gullies and scald surfaces has yielded no discernible differences between rabbit-free and rabbit-grazed areas. However, the edges of bare-soil scalds are contracting more in the rabbit-free areas.

# **CONCLUSIONS**

The correct technique for warren ripping is essential for effective rabbit control and will also save money by reducing the amount of follow-up work required.

The preliminary data suggest that there are likely to be substantial benefits to pastoral production from rabbit control. Sheep grazing has increased in rabbit control areas, but pasture condition appears to be improving at the same time. Large increases in kangaroo numbers in the absence of sheep indicate the need for management of total grazing pressure after rabbit control.

Perennial plants are important for the long term stability of the pasture. Although perennial plants have increased in both rabbit-grazed and rabbit-free areas, the response has been better in rabbit-free areas. The number of plants that survive the next dry period will be a test of the benefits of rabbit control.

So far the results indicate a marginal improvement in pasture quality and quantity in the rabbit-free areas. As with perennial plant increases, the benefits of rabbit control for the pasture may be better demonstrated after a dry period.

The excellent growth of vegetation has limited water run-off on all sites and until the quantity of pasture varies between treatments, there is unlikely to be any discernible differences.

The contraction of the bare scalds in rabbit-free areas may be a result of good seasons, and until a drier period is experienced, it will not be known whether this contraction difference is permanent or significant.

# INTEGRATED KANGAROO MANAGEMENT: A CO-OPERATIVE APPROACH TO KANGAROO CONTROL WITHIN THE IVANHOE LANDCARE GROUP

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### **ABSTRACT**

There is abundant evidence that indicates kangaroos compete strongly for forage and water supply. In some areas of western NSW, kangaroos and goats account for more than 50% of total grazing pressure. This competition provides for reduced livestock productivity (Wilson 1991), in addition to damage to property improvements (Norbury 1992) - with a resultant loss in farm income.

In order to increase the impact and ease of kangaroo control, the Ivanhoe Landcare Group trialled several different modifications of the "Findlayson Trough" technology (Norbury 1992, Butcher 1993), an electrified wire which excludes kangaroos from drinking at troughs and ground tanks. The Landcare group wished to determine the effectiveness of the Findlayson Trough technology in congregating kangaroos around watering points, thereby increasing the ease of harvesting.

The trials illustrated that the effectiveness of the system was high, with 95% of kangaroos observed unable to drink at electrified troughs and 98% unable to drink at electrified ground tanks. Ability of the system to congregate kangaroos around waters was impressive. Over the trial period, the population around electrified waters was increased, on average, by a factor of 2.6.

#### INTRODUCTION

The trials were carried out over three properties, approximately 45km south of Ivanhoe, in the Western Division of NSW. The main objective of the research was to determine if kangaroos could be controlled with greater ease and effectiveness, over large areas. The Findlayson Trough technology (Norbury 1992) was used in an attempt to concentrate kangaroos around strategically selected waters in order to increase harvesting efficiency.

A co-operative approach to the implementation was needed, in order to overcome the constraints of property boundaries and to pool resources. This co-operative approach allowed a licensed shooter to trial the system across three adjoining properties. This paper is a brief overview of the research that was carried out by the Landcare group, in conjunction with the author.

# **METHODS**

Variations of the Findlayson Trough design were constructed on selected troughs and ground tanks. The general design of the wires followed recommendations as discussed by Norbury (1992) and Butcher (1993). Three sites were established:

- (i) Site A comprised 3 ground tanks in an area of approximately 2km radius, taking in three adjoining properties. These wires acted as "exclusion wires", designed to exclude kangaroos and livestock from the water.
- (ii) Site B a control for Site A, consisting of three non-electrified earth tanks, over the boundary of two properties. Again, these waters were in an area of about 2km radius and in similar country.
  - These two comparison sites were approximately 10km apart, which was considered sufficient distance to prevent drift of kangaroos from one area to the other, which could give a biased result (Hacker 1993).
- (iii) Site C a series of 6 electrified troughs and 2 earth tanks, to monitor kangaroo and livestock behaviour on a number of different designs. This series of electrified waters also provided shooters with an indication of the ease and productivity of harvesting while driving a direct route around the waters.

Monitoring was done at regular intervals prior to and during the trial, along with observations from a licensed shooter who maintained a record of kangaroo behaviour and population dynamics.

#### RESULTS

The effectiveness of the Findlayson Trough system in excluding kangaroos from troughs and ground tanks was high. 95% of kangaroos observed were unable to drink at troughs, and 98% were unable to drink at ground tanks. Those that did gain access to water, did so by chance. Either animals were too small to contact the wire on troughs, or irregularities in the banks of ground tanks allowed an area for kangaroos to jump onto, away from the wire. The latter situation only occurred after 3-4 days, when animal's level of thirst had increased and the behaviour appeared learnt, as the kangaroo avoided the wire with an almost "sideways" bound.

Livestock watering at electrified troughs received minimum disturbance. Those that did receive shocks from direct contact with the wire (about 10% of sheep and 5% of cattle), returned to drink soon after. Wires at the ground tanks were effective in excluding 100% of livestock observed. These results are compatible with those obtained by Norbury (1992) and Butcher (1992).

Table 1. Effectiveness of the Findlayson Trough system in congregating kangaroos around watering points. Numbers observed during a one hour period within a 1km radius.

Run No.	Electrified site A	Non-electrified site B
1	32	21
2	94	36
3	90	16
4	56	23
5	34	20

As illustrated in the table above, the congregation of kangaroos at the electrified site was substantially increased, especially during the 2nd and 3rd night of the trial. After that time, numbers started to decline.

Average costs of constructing the system were \$133.34/trough, involving 1.6 hours labour; and \$182.03/ground tank, utilising 2 hours labour.

# **DISCUSSION**

The results obtained in this trial indicate the-high effectiveness of the Findlayson Trough technology in excluding kangaroos from stock waters and congregating the animals in the vicinity of those waters. As indicated by the research, kangaroos will congregate at the electrified waters for 5-6 days, during which time efficient harvesting can be undertaken. After the program has been implemented for an area, the equipment can be installed in another region. Implementation of this system on a co-operative basis allows larger areas to be covered thereby increasing effectiveness of control.

It is feasible to incorporate this control system into graziers' management routines, allocating a period each year in which harvesting is undertaken. This has the opportunity to create better kangaroo control and additional income. If the electrified waters were installed as part of a property's water-run, harvesting could be carried out while checking these waters at night, as part of the normal management routine (Butcher 1994).

# **ACKNOWLEDGEMENTS**

The Ivanhoe Landcare Group provided funding for this research. Trial sites were provided by Graham and Ros Rees, Ron and Marie Rees - "Peneena", Edward and Kylie Rees - "Retreat", and Jim and Prue Graham - "Carinya". David Butcher, Rob Richards and Ron Hacker provided technical assistance. Graham and Ros Rees also provided resources and accommodation.

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# PRELIMINARY SUCCESS IN CONTROLLING FEATHERTOP (ARISTIDA LATIFOLIA) WITH LOW RATES OF GLYPHOSATE

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# **ABSTRACT**

Two pasture topping treatments were trialled at two sites for the control of feathertop, a wool contaminant of the mitchell grasslands. Feathertop palatability was enhanced, and the germinable seed bank reduced. The ultra low volume application appears to have the greatest potential.

#### INTRODUCTION

Feathertop (*Aristida latifolia*) costs Queensland's woolgrowers up to \$5 million in direct deductions annually (Filet 1990). Its dart-like seed is the major wool contaminant from western Queensland's mitchell (*Astrebla* spp) grasslands. It is a native of these clay soils, thus posing a challenge at attempts to managing the problem (Lee *et al.* 1980). One possible solution is the use of low rates of glyphosate (pasture topping). Pasture topping can increase palatability of grasses (Armstrong *et al.* 1992) and reduce seed viability. Feathertop is an unpalatable grass. It relies heavily on seed production to increase its population during wet seasons. This paper presents results of trial work to date.

#### **METHODS**

Areas within two commercial properties ("Abrach", west of Muttaburra Qld: and "Dilulla", north of Longreach Qld) were aerially sprayed with Roundup CT, at rates of 200ml Roundup/ha, in March 1993. Feathertop was in early to late seed set at each site. Two application media were used: EC (water based) and ULV (ultra low volume, oil based). Total liquid application was 20 l/ha and 2 l/ha respectively. The treatments were not replicated at either site. Pasture yield, % feathertop grazed and germinable seed bank were assessed 20 weeks after spraying. Post spraying management was normal for each property and varied from light to moderate grazing pressure.

## **RESULTS**

The proportion of feathertop grazed was greater for the EC treatment, and highest at "Dilulla" (Fig 1).

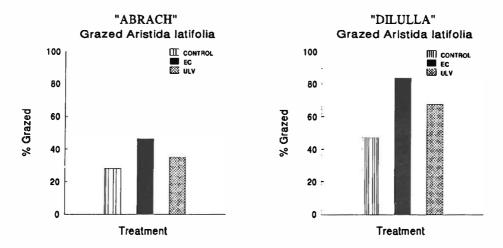


Fig 1. Proportion of feathertop (Aristida latifolia) grazed at 2 sites following pasture topping.

The germinable seed bank of Aristida tended to be lower where sprayed, as did Astrebla (Fig 2).

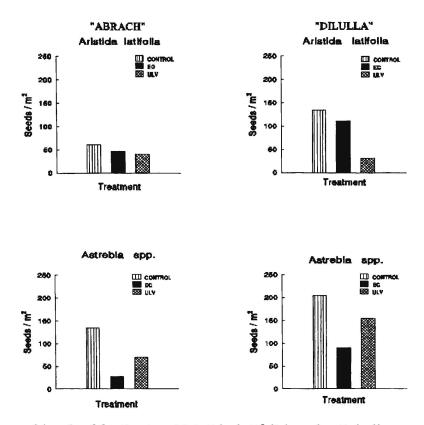


Fig 2.Germinable seed bank of feathertop (Aristida latifolia) and mitchell grass (Astrebla spp.) at 2 sites following pasture topping.

The ULV treatment reduced the potential feathertop germination by the largest extent, but the mitchell by the least.

# **DISCUSSION**

The trends were similar at both "Abrach" and "Dilulla", with the pasture topping reducing the germinable seed bank and increasing palatability of feathertop. These results are encouraging, indicating there is scope to reduce the amount of feathertop germinating after rain. The degree of grazing induced would probably not be sufficient to damage mature plants although it may provide additional grazing and some benefits to production. Reducing feathertop recruitment would seem to be the key to reducing pasture infestations.

The ULV treatment looks most attractive, having reduced the feathertop seed bank by the greatest degree. It is also preferable for practical reasons, as the requirement for water, as a mixing agent, is much less than the EC treatment. Unfortunately, both the ULV and EC treatments reduced the level of germinable mitchell grass seed. ULV had the least effect. The potential to damage the desirable mitchell grass component of the pasture would seem to be less with ULV application.

# **ACKNOWLEDGEMENTS**

We wish to thank both AWRAPO and Monsanto for funding this work.

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# WEED MANAGEMENT: AN ESSENTIAL PRACTICE FOR SUSTAINABLE RANGELAND PRODUCTION

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#### **ABSTRACT**

Rangeland degradation through weed invasion is well documented in Australia and internationally. Rangeland weeds reduce profits, increase operational costs, degrade the natural environment and increase the maintenance requirements of infrastructure. A comparison of the value of pastoral production with the estimated cost of treating existing noxious weed infestations in the Northern Territory demonstrates the severe impact and threat posed by weeds. Native woody species also have the potential to have a deleterious effect on current and future land use. Increasing demand for "clean produce", sustainable development, and the use of rangelands for conservation, tourism, defence, and mining, compel stronger action in rangeland weed control.

#### THE PROBLEM

Weeds are a cause and a symptom of environmental change. Several causes of weed invasion of rangelands have been identified, including overstocking, changes to the burning regime, long term climatic variation and the introduction of exotic species. Pastoral activities have contributed to, and suffered from, the weed problems in rangeland areas of the Northern Territory. Woody species such as parkinsonia (Parkinsonia aculeata) and Athel pine (Tamarix aphylla) were introduced on purpose for shade or amenity, while species such as rubber bush (Calotropis procera) were accidentally introduced. Government records indicate that many herbaceous species including Noogoora burr (Xanthium occidentale), Devil's claw (Martynia annua), goat's head (Acanthospermum hispidum), Sida spp and Senna spp were probably introduced to the Northern Territory with contaminated hay, seed, livestock or machinery. Invasion of rangelands by introduced species and native woody weeds constitutes a major threat to the sustainability of pastoral production through competition with pastures, toxic effects, contamination of produce, the blocking of access to watering points, and interference with fencelines and mustering activities. For example, rubber vine currently costs the North Queensland cattle industry in excess of \$10 million annually through lost production and control costs. Under the Northern Territory Noxious Weeds Act, landholders carry the responsibility for noxious weed control. Many landholders, however, do not recognise the long-term threat posed by weeds, the cost-effectiveness of preventing their introduction, or the importance of controlling infestations before they become extensive. The low human population, seasonal access limitations and large property sizes exacerbate weed management difficulties.

# THE COST

It is difficult to put a dollar value on the degradation caused by weed invasion. Increasing populations of weeds clearly undermine sustainable pastoral production in the long term, but how can the immediate problem be quantified? An estimate of the area infested by noxious weeds in the Northern Territory and approximate treatment cost is shown in Table 1. The figure of \$115.2 million includes herbicide and application costs for one year, but does not include labour or equipment purchase. In reality, most of these infestations would require follow-up treatment for several years. In contrast, pastoral production in the Northern Territory was valued at \$91.1 m in 1991 (Coulter, 1992). Although significant, the total infested area of more than 1 million ha is only a small portion of the total area threatened by invasion. Also, weeds tend to invade high use areas such as watering points and yards, or ecologically important areas such as floodouts and along water courses. The total area infested, therefore, is a conservative indication of lost productivity and environmental threat. The question must be asked, how long can rangeland industries be sustained while this serious form of land degradation continues?

# WHAT IS THE SOLUTION?

Government assistance schemes and taxation concessions are available to landholders for weed control, but strategic weed management is generally lacking. This trend is likely to continue unless

changes are made. Five strategies are suggested to achieve effective weed control in rangelands:

- \* Integrate weed management with other land management practices.
- \* Obtain a long-term commitment to weed management by all landholders, industry, the community and Government.
- \* Develop a strong research base for weed management.
- \* Develop more effective quarantine measures and regulatory legislation.
- \* Increase Government input into the management of weeds.

Landholders must gain a better understanding of the insidious threat posed by weeds as effective weed management is essential to achieve sustainable rangeland production.

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Table 1. Estimated area infested by noxious weeds in the Northern Territory and approximate herbicidal treatment cost for one year.

Infestations of noxious weeds in the Northern Territory		Est. infestation area: scattered to dense		cidal application at wages)
Botanical Name	Common Name	Total Ha	\$Aus/Ha	TOTALx1,000\$Aus
Acacia catechu	Cutch tree	1	100	.1
Acacia nilotica	Prickly acacia	450	150	67.5
Acanthospermum hispidum	Goat head	6000	50	300
Alternanthera pungens	Khaki weed	15500	50	775
Asphodelus fistulosus	Onion weed	0	0	0
Calotropis procera	Rubber bush	43200	600	25920
Carthamuslanatus	Saffron thistle	50	50	2.5
Cenchrus echinatus	Mossman River grass	3000	80	240
Dalbergia sissoo	Dalbergia	5	200	1
Datura ferox	Thornapple	20000	50	1000
Echium plantagineum	Paterson's curse	5	50	.3
Eichhornia crassipes	Water hyacinth	1	200	.2
Emexaustralis	Spiny emex	0	0	0
Hyptis suaveolens	Hyptis	140000	50	7000
Jatropha curcas	Physic nut	0	0	0
Jatropha gossypifolia	Bellyache bush	1100	200	220
Lantana spp.	Lantana	55	80	4.4
Leonotis nepetifolia	Lion's tail	200	100	20
Lycium ferocissimum	African boxthorn	1	100	.1
Martynia annua	Devil's claw	1000	100	100
Mimosa pigra	Mimosa	80000	150	12000
Mimosa pudica	Common sensitive plan	•	200	2
Opuntia spp.	Prickly pear	500	200	100
Parkinsonia aculeata	Parkinsonia	230000	150	34500
Parthenium hysterophorus	Parthenium weed	1	100	.1
Pennisetum polystachion	Mission grass	10000	100	1000
Pistia stratiotes	Water lettuce	100	100	10
Prosopis limensis	Mesquite	10100	200	2020
Salvinia molesta	Salvinia	200	200	40
Senna alata	Candle bush	1000	100	100
Senna obtusifolia	Sicklepod	55000	80	4400
Senna occidentalis	Coffee senna	5100	80	408
Sida acuta	Spinyhead sida	140000	60	8400
Sida cordifolia	Flannel weed	55000	60	3300
Sida rhombifolia	Paddy's lucerne	41000	60	2460
Stachytarpheta	Snake weed	10500	100	1050
Tamarix aphylla	Athel pine	2500	600	1500
Tanus ocuprigita Themeda quadrivalvis	Grader grass	31000	100	3100
Tribulus spp.	•	11500	50	575
Trwuius spp. Xanthiumoccidentale	Caltrop	91000		
	Noogoora burr		50 50	4550
Xanthium spinosum Ziziphus mauritiana	Bathurst burr	20 100	50 80	1 8
	Chinee apple			
TOTALS		1,005,199		115.2m

Source: Weeds Officers of the NT Department of Primary Industry and Fisheries.

# MANAGEMENT OF FERAL DONKEY POPULATIONS IN KIMBERLEY RANGELANDS OF WESTERN AUSTRALIA

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#### **ABSTRACT**

Feral Donkey (*Equus asinus*) populations in the Kimberley region of Western Australia (421,451 km²) have been reduced by 90% since 1980, through co-ordinated aerial shooting programs. Aerial surveys estimate population levels to be about 0-1 donkeys/km². Donkeys have historically been a significant grazing pressure in the Kimberley but now that total grazing pressure has been reduced to its lowest level for 60 years, an opportunity exists for rangeland recovery. Aerial shooting traverses are logged and mapped using global positioning and geographic information systems to improve efficacy and efficiency of control programs.

#### INTRODUCTION

Feral donkeys are the descendants of pack and draft animals used in the development of the Kimberley region in the late 19th century. Large donkey populations were present in the Kimberley by the 1940's. Feral donkeys were declared vermin in the Halls Creek area in 1949 and in the West Kimberley in 1954 (Long 1988).

In the 1960's and 70's it was estimated that many Kimberley pastoral leases had more than 10,000 donkeys on them. Aerial surveys in the East Kimberley in 1980 indicated there was about one feral donkey to every three head of cattle (1/km², Gowland 1980).

There have been no specific studies published of damage caused by feral donkeys in Australia. Feral donkeys are in direct competition with cattle for pastures. They are part of the total grazing pressure on rangelands. The pads or trails created by donkey movements contribute to erosion.

Feral donkey populations can increase rapidly. 64% of jennies taken in the Hardman Basin area (Kimberley/ Northern Territory) were pregnant and 21% showed other signs of reproductive activity (e.g lactation, ovarian activity). Only 10% showed no reproductive activity, and most of those were < 1 year old (McCool*et al.* 1981). Feral donkey populations increase by about 22% per year on average. That level of control is necessary to maintain population levels.

# CONTROL

Poisoning has been impractical because of the presence of cattle and native animals while ground shooting programs are restricted by access. Large numbers of donkeys have been shot (e.g. 70,000 shot between 1978 and 1981 by pastoralists in the East Kimberley) and ground shooting by pastoralists continues to be a valuable contribution to overall population reduction. This is especially so where population numbers are relatively low. Ground shooting is a backup to the main control thrust which is aerial shooting. A 50% subsidy on the purchase of approved calibre ammunition (.243 and .308) for organized control programs encourages ground shooting.

Co-ordinated aerial shooting programs have been the key to wide scale and sustained reduction of feral donkey populations across the Kimberley region.

## **FUNDING**

In Western Australia pastoral lessees pay a yearly levy based on the estimated unimproved value of their lease to assist with control of declared plants and animals. In the Kimberley region that rate is currently 2.63 cents in the dollar of unimproved value.

Funds raised from this levy are matched dollar for dollar from the Western Australian State Government and placed into a State Declared Plants and Animals Control Fund (DPACF). Allocations from this fund are made to statutory authorities - Zone Control Authorities (ZCA's) - around Western Australia, for the control of declared plants and animals.

ZCA's are comprised of producer and community representatives. They ensure grass roots input into strategies to deal with pests of agricultural significance to Western Australia. They also allocate funding to control programs.

Average annual expenditure on feral donkey control in the Kimberley is;

\$40,000	Direct state government funds for control on	Government/Crown Land
\$180,000	D P A C F for control on pastoral leases	
\$220,000	Total (excluding salaries)	

#### RESULTS AND DISCUSSION

Annual helicopter shooting programs have been carried out in the Kimberley since 1979 by the Agriculture Protections Board of Western Australia (APB). The impetus for this control effort has come from producer and community representatives through Zone Control Authorities. Over 500,000 feral donkeys have been shot from helicopters with an unknown number controlled by pastoralists.

Aerial surveys conducted at three-yearly intervals indicate that a 90% reduction in feral donkeys populations has been achieved. Average density of donkeys across the Kimberley has been reduced from about 1 donkey/km² to 0.1 donkey/km². Results from aerial shooting and observation confirm this reduction. In the mid 1980's it was common for >100 donkeys/hour to be shot from each helicopter. Average numbers now being shot are around 25 donkeys/hour and that is from a helicopter and spotter aircraft working in tandem.

Spotter aircraft have been used extensively since 1991. They are effective at locating feral donkeys and directing a helicopter to them, particularly when the local knowledge of pilots and pastoralists is utilised.

Aircraft are arranged by state tender. A tender system ensures the most competitive price and allows for quality assurance of aircraft, company and pilots. It also allows an uninterrupted control program. Bell 47 helicopters and LIAI self-loading rifles have been used for over 90% of control work.

Aerial shooting programs are conducted between August and October each year. At this time, surface water is reduced and feral donkeys are concentrated to some extent making control programs more efficient.

Aerial shooting transects are logged using global positioning system equipment. Records of donkeys found and shot at given locations are recorded and this information is mapped through geographical information systems on a lease by lease basis. This provides an effective and objective way of knowing exactly where aerial searches and control has taken place and determining where donkey populations are likely to be found. This information makes control programmes more efficient.

Eradication of feral donkeys from defined areas using radio telemetry techniques may be possible once numbers have been substantially reduced. Eradication trials commence in 1994.

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# POPULATION DYNAMICS AND AVERAGE ANNUAL GROWTH RATES OF A WEST AUSTRALIAN WOODY WEED, Hakea preisii.

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## **ABSTRACT**

Hakea preissii has become a woody weed over large areas of Western Australia's semi-arid pastoral shrublands. Data from a long term exclosure in the west Gascoyne area near Carnarvon show that both mortality rates of old (>24 years) individuals and average annual recruitment rates are very low. Average annual growth rates are also very low. The management implications for control of this species are discussed.

### INTRODUCTION

The problem of woody weed encroachment on pastoral lands is not as well recognised in Western Australia as it is in the eastern states, however a large proportion of the shrublands of Western Australia either suffer from woody weed invasion or are susceptible to invasion.

Hakea preisii or needle bush is one such woody weed, a tall shrub or tree found throughout the semiarid shrublands of WA but especially invasive in the Upper Gascoyne and west Gascoyne areas of W.A.

This paper provides some information about the survivorship, recruitment and average annual growth rates of *H. preisii*.

### **METHODS**

A large exclosure (approx. 4ha) was erected on an area of degraded Currant Bush Mixed Shrub pasture in the Carnarvon area in 1968. Fifty four permanent transects were set up in 1969 inside the exclosure, each measuring 30.5m by 183cm (100ft by 6ft) and all established shrubs mapped. Initial *H. preisii* density was about 350 plants/ha, a moderate to high invasion density for this area.

Various combinations of mapping, counting and measuring the size of the shrubs were made in 1969, 1970, 1973, 1975, 1980, 1982, 1985 and 1993. The fate of individuals was followed by using the coordinate positions of individuals in 1993, and retrospectively mapping back to the initial recording. A survival table was then calculated.

### **RESULTS**

The total population size, number of recruits and survivorship of individuals is shown in Table 1.

Table 1. Hakea preisii survivorship inside the exclosure, March 1969 - Sept 1993. Population values are grouped by "cohort" (year first observed) and show the number of individuals alive at each census date.

Cohort	Mar 1969	1970	1973	1975	1980	1982	1985	1993	
pre-69	113	108	107	107	99	99	97	95	
1970		2	1	1	1	1	1	1	
1973			0	0	0	0	0	0	
1975				0	0	0	0	0	
1980					5	5	5	5	
1982						1	1	1	
1985							0	0	
1993								1	
Total	113	110	108	108	105	106	104	103	

Of the 108 individuals present in 1969, 91 (84%) were still alive in 1993, giving an average annual

mortality of 0.0067%. Recruitment rates were very low, with only 9 (8% of original population) confirmed recruits since 1969.

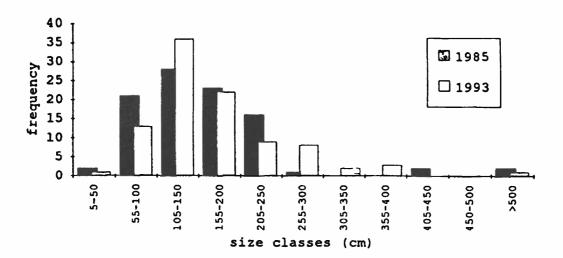


Figure 1. Size class distribution (maximum horizontal intercept) for all individuals of the pre-1969 cohort alive in both 1985 and in 1993.

Size class data from Figure 1 show that 93% and 84% of the population were between 50cm and 250cm wide in 1975 and 1993 respectively. Maximum widths for fully grown *H. preisii* can be as much as 800cm and are generally at least 350cm. Data from a nearby site suggest that *H. preissii* produces flowers and seeds when width reaches about 150-200cm.

## **DISCUSSION**

Recruitment rates between 1969 and 1993 were very low in this exclosure, however popular wisdom suggests that *H. preissii* recruits in large numbers after a sequence of good seasons and that most of the individuals reported here recruited in the mid 1960's. Irrespective of whether *H. preisii* recruits in large numbers sporadically or as a "trickle" over time, recruitment is low in almost all years.

Average annual growth rates are also very low with 98% of the pre-1969 cohort still less than half their potential width after 24 years, and little change in average size in the seven years between 1985 and 1993.

Hot fires have been shown to kill *H. preisii* (Holm *et al.* 1993), although the fuel loads necessary to achieve this are a very infrequent occurrence. Other types of control such as chaining or poisoning are prohibitively expensive although the timing of these events is largely at the convenience of the land manager, since both recruitment and growth rates are low. The cost of such control can be discounted over at least 20 years.

#### **ACKNOWLEDGEMENTS**

Roger O'Farrell initiated the study in 1968. A large number of departmental staff have helped record this site over the last 24 years.

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# **EXTERNAL CONSTRAINTS TO BEST PRACTICE IN RANGELAND MANAGEMENT**

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#### **ABSTRACT**

"Best practice" in pastoral rangeland management relates to decisions which provide sustainable productivity and profitability. External constraints to rangeland management include finance, government policy / land administration, input costs / commodity prices and options for diversification. In some situations these may be constraints to "best practice". However, there is opportunity for graziers to reduce the negative impacts of these external constraints.

# **EXTERNAL CONSTRAINTS TO PASTORAL MANAGEMENT**

Pastoral rangeland management has always been affected by external constraints, i.e. policies of both government and private enterprise. External constraints have been changing and intensifying over the past decades - and some may now be a significant constraint to "best practice".

"Best practice for practical (pastoral) rangeland management in Australia" may be defined as decisions which provide sustainable productivity and profitability. Inherent to "best practice" is the necessity for graziers to be able to make decisions which integrate all the factors that affect their business.

External constraints to decision making are usually outside of the graziers opportunity to change. They include financing, government policy / administration, input costs / commodity prices and options for diversification. Any external constraint which results in reduced long-term profitability usually causes increased pressure on the rangelands resource.

# **FINANCE**

The high interest rates of the late 80's and early 90's resulted in a significant financial pressure on otherwise viable enterprises. Lending institutions need to employ a borrowing system which is not rigidly tied to financial market interest rates and which is more attuned to the vagaries of primary production.

# **GOVERNMENT POLICY / ADMINISTRATION**

Government policy / administration covers issues from international agreements to local government by-laws. Changes in state government legislation have had the greatest impact. Whilst some have had sound scientific basis, others have been motivated by political pressure or administrative convenience.

Queensland's move to base rental on unimproved capital value (rather than carrying capacity) will introduce a significant cost which is quite unrelated to the productive capacity of the land.

# INPUT COSTS / COMMODITY PRICES

When costs increase unrealistically, profit margins decline significantly. Input costs are often related to what the general market will accept for more profitable (per unit area) enterprises. The "tyranny of distance" factor exacerbates these costs for remote properties. Co-operative purchasing may provide opportunities of minimising costs.

The commodity price is usually the primary factor governing profitability. Whilst market demand and access are primary factors in commodity price control, marketing arrangements can provide significant differences. Groups of wool producers in Qld. have found that direct contact and sales to overseas mills has enhanced their net return.

# **OPTIONS FOR DIVERSIFICATION**

Most pastoral properties have single enterprise production. The lack of options for large scale diversification may constrain "best practice" by restricting returns to financial cycles.

Whilst seasonal conditions will be a primary factor in all livestock production, opportunities for diversification of income base are generally increasing, e.g. outback tourism, kangaroo harvesting and intensive production on small areas.

# **FUTURE DEVELOPMENTS**

Whilst several external constraints may limit "best practice", there is some opportunity for graziers to reduce the impact of these constraints.

# FINANCIAL FEASIBILITY OF INVESTING IN AN ELECTRIFIED TROUGH SYSTEM TO CONTROL KANGAROO GRAZING

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### **ABSTRACT**

The financial feasibility of investing in an electrified trough system is analysed for a property located in the Western Division of NSW using RANGEPACK computer software. Conservative estimates of productivity gains, as a result of restricted grazing by kangaroos, are interpreted financially. Running business returns and cash surplus are shown to be improved by \$45000 and \$82000 respectively over a ten year period by implementing the electrified trough system.

# **INTRODUCTION**

Kangaroos compete with sheep for the same basic food and water resources when grazing a common pastoral environment (Grice 1992, Wilson and Harrington 1984, Caughley, *et al.* 1987). This competition is greatest when conditions are poor and pasture biomass is low. Results of work undertaken in Western Australia with the Finlayson trough (Norbury 1993), and at "Palapah", western NSW, (Butcher *et al.* 1993) indicates that selective electrified watering devices potentially offer an effective means of kangaroo control in pastoral areas. Butcher *et al.* (1993) stated that using electrified troughs on "Palapah" had undoubtedly made a substantial contribution to good flock performance, as measured by wool cut and lambing percentages.

Investment costs to convert to an electrified trough system are relatively low if existing access to water is by troughs. However, if waters are open there are significant costs of conversion. An assessment of the subsequent production gains is necessary to justify the investment cost.

#### **METHODS**

The enterprise that is studied is a 41700 ha property with a maximum breeding ewe flock size of 4500. Productivity estimates for different year-types (good, okay, poor and bad) have been based on actual data supplied by a grazier (see Table 1). Land system was soft red earth, rosewood-belah country with average annual rainfall of 280mm.

RANGEPACK, a computer modelling program, was used to establish the feasibility of setting up the electrified trough system over a period of ten years. This option was compared with current management, which utilises commercial shooters to cull kangaroos. The investment was made in 2 stages over the first 3 years. A total of 15 waters are converted to electrified troughs with 11 of them requiring major infrastructure such as fencing, tanks and troughs. The total cost of the investment was \$25150.00 (\$15500 in year 1, \$9650 in year 2).

Exclusion of kangaroos was estimated to reduce grazing pressure on 65% of the area. Increases in productivity are reflected in a sequence of slightly better years for the electrified trough system (see Table 2). Productivity gains were only assumed during seasons defined as poor or bad, since kangaroos and sheep compete more actively at this time (Caughley *et al.* 1987). Seasons or year-types reflect expected productivity levels as influenced by probable rainfall. However they are not exclusive.

Table 1. Productivity as described by year-types.

		J 1			
Year-type	Good	Okay	Poor	Bad	
Weaning %	90	75	65	20	
Mortality %	10*	8	10	25	
Wool kg/hd	8.5	7.5	6.5	6	

<sup>\*</sup>More deaths anticipated in a good year due to problems such as spear grass damage and fly strike.

Table 2. Year sequences assumed for (A) "electrified trough system" and (B) "current management" over a ten year period.

Year	1	2	3	4	5	6	7	8	9	10	
Α	poor	good	okay	okay	okay	okay	okay	poor	okay	okay	
В	poor	good	okay	okay	poor	okay	poor	bad	okay	okay	

#### RESULTS

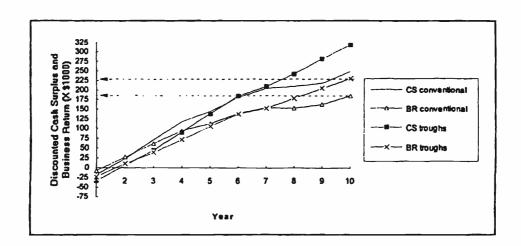


Figure 1. The running net cash surplus (CS) and business return (BR) for two management options using a 620c/kg market indicator price.

# **DISCUSSION**

Investment in an electrified trough system is shown to yield a superior net present value, in terms of net cash surplus and business return over a 10 year period. Increases in productivity were not gained until year 7, as dictated by the year-types. The trough system becomes more profitable when available forage is limited.

The trough system may yield other non pecuniary benefits. Income and production variability may be reduced and the welfare of livestock may be enhanced. The reduction of total grazing pressure and increased control over existing herbivores would aid the grazier in managing against land degradation induced by overgrazing and assist them to manage for regeneration.

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#### FINANCIAL RISK ANALYSIS - THE SLEEPING DOG OF TECHNOLOGY TRANSFER

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#### **ABSTRACT**

Primary producers in Australia are having to quickly make unprecedented changes in their management practices in order to remain financially viable. Increases in productivity has accommodated the declining terms of trade in the past but it is argued that in the future, sustained profits will require the additional skills of business and risk management. It is recommended that research and technical advice to primary producers be accompanied by the associated economic and risk effects of adoption.

#### INTRODUCTION

The treatment of pastoralism as a business first and foremost will be a fundamental requirement for the survival of both the rangeland ecology and the many small businesses using rangeland resources. A rangeland manager can cause serious damage to the resource when operating under either of two scenarios. Scenario one exists when business return is the sole purpose for the activity and maintenance of the land resource is of no concern. This can be due either to ignorance or irresponsibility. The second scenario is where the manager is a responsible guardian of the land resource, but due to the inability to effectively manage the business aspects of the operation, financial resources are at times inadequate to afford effective rangeland management practices.

# HISTORY OF PASTORALISM IN AUSTRALIA

Historically, Australian pastoralists have managed the declining terms of trade using a series of tactics. The current position is that the productivity improvements from science have increased the supply of food and fibre faster than it can be absorbed by the market which is distorted by protectionism in world trade and a lack of purchasing power in the developing countries. Profit margins have been reduced to a level in many areas of primary production such that business survival may be determined by skilful business management and specifically, the management of risk.

Australian primary producers have a brilliant production performance. The then head of ABARE Dr Robert Bain showed in 1987, that primary producers qualified as a sunrise industry when assessed against the five criteria laid down by the government of the day for eligibility to special support for the emerging high tech. industries. Productivity improvements in primary industry have been thirty per cent greater than in secondary industry over the last twenty years. This performance record leads me to believe that our force of managers has more than enough capacity to take on the new skills of modern business management if given the opportunity.

# **BUSINESS SUPPORT FOR PRIMARY PRODUCERS**

The business support to primary producers has been inadequate for much of the history of Australian agriculture. Bank managers have been finance salesmen and accountants have managed the taxation effects of primary production. Government advisory services to primary producers have focused on production. It is only in recent years that private consultants have gained a foothold in the industry by providing, in most cases a hybrid service of biological and business management advice.

# INCORPORATING RISK MANAGEMENT INTO RANGELAND ADVISORY SERVICES

The rangeland businesses in Australia today deserve advisers and researchers who can provide technological advice which is supported by data to enable the farm business managers to determine the financial, economic and risk effects of implementing technology. Conservative management has been shown by Newman (1993) to be the most successful management strategy in the long term in south western Queensland. The conservative managers appreciated the need to accommodate risk in a land renowned for large fluctuations in prices and rainfall.

Advisers to primary producers can provide a valuable service by couching all technical advice in an economic and financial context. Numerous biological and mathematical computer models are readily available to test the bottom-line ramifications of any new technology.

The Western Australia pastoral industry is well serviced with the herd and financial model PASTOR. This model can, with a minimum of training, be used to closely examine both the financial and economic effects of any alternative management strategy.

This paper recommends that each technology recommendation should be supported by advice on the estimated effect it has on business return and exposure to risk. Simplified methods to manually assess these parameters could be supplied with each technology package as a matter of course. Research funding bodies could insist on the supply of detailed business and risk assessment analyses of all applied research projects.

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#### STUDYING JUDGMENTS MADE IN MANAGING RANGELANDS

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#### **ABSTRACT**

Human judgments are required in the management of inherently uncertain systems. The nature and quality of judgment behaviour in the rangelands is worthy of investigation. These judgments can be represented mathematically, thereby providing a means for comparing and contrasting individual performance. This objective capture of judgment behaviour provides a potentially valuable research and interactive learning tool for use in the rangelands.

# INTRODUCTION

The pervasive uncertainty of natural environments requires the frequent exercise of judgment in the decision making process. In the rangelands, environmental cues are used to make tactical judgments and decisions by land holders, scientists and advisers. Further advances in either the knowledge base or in the tools supporting decision making are unlikely to remove completely the need for skilled, timely judgments made as part of management. Although the consequences arising from this human activity can be great, people working in natural environments have generally not concerned themselves with a rigorous examination of the nature of the judgments made. This represents a potential area for intellectual and applied development in rangeland research and practice.

The exercise of human judgment, generally thought to be a mysterious cognitive activity, can be subjected to rigorous analysis and representation using multiple regression techniques (Brehmer and Joyce 1988). This poster describes the use of techniques developed within the psychological approaches to the study of judgment and decision-making to investigate judgment behaviour in three routine judgment problems in rangeland management.

# **METHOD**

Social Judgment Theory has been used to investigate judgment behaviour in a wide range of situations where people must use specific available information (or "cues") to make an assessment of an unknown and uncertain (or probabilistic) criterion (Hammond *et al.* 1975). The judgment 'problem' is matching their use of information to the optimum relationships between that information and the criterion. This process is conceptualised in a 'lens model' which consists of the physical environment and the cognitive (human environment) located either side of the mediating information or cues drawn from that physical environment.

The process of judgment analysis or 'policy capturing' uses multiple regression to relate the information sources (cues) to a person's judgment of a criterion, over a sufficiently large number of cases. Reliability in judgment can be tested with repeat cases. The regression statistics represent a person's 'judgment policy'. The multiple correlation coefficient (R) is a measure of a person's consistency of information use in judgment. The regression weights, variously expressed for individual cues provide a measure of the relative importance of each cue. These statistics can be used to compare between people's subjective assessments of a criterion and known, optimum or objective measures for that criterion. Further, the approach provides a means of feeding back interpretable and meaningful information to individuals about their performance in judgment, and comparing that performance with others.

Judgment analysis within this paradigm was used to build models of: the visual assessment of range condition (Pringle *et al. pers. comm.*); the judgment of tactical stocking rate using environmental information; and the judgment of change in range condition using monitoring site data (Burnside and Faithfull 1993).

#### RESULTS AND DISCUSSION

**How good is the land?** The assessment of range condition made as part of extensive rangeland inventory and condition surveys.

Visual assessments of range condition made by skilled workers ('subjective') at many sites were compared within a lens model with ecologically derived assessments of range condition generated using biological attributes measured at the sites ('objective'). Using this approach permitted the measurement of the level of linear and non-linear similarity between the assessments. It also identified the important biological indicators in the 'subjective' and 'objective' assessments. The adequacy of 'objective' - 'subjective' agreement varied markedly between vegetation types. Low agreement between 'subjective' and 'objective' assessments can be separated into the influence of low human consistency in performance, and low linear similarity between the visual and ecologically derived rules for the importance of the biological attributes. This approach can be used to check the adequacy of 'subjective' assessment, to determine decision rules to be applied during visual assessment of range condition in the field, and to provide a basis for interactive training for people working in the field.

**How many sheep?** The judgment of tactical stocking rate made using technical information describing the rangeland environment.

Judgment rules used in assessing tactical stocking rate (sheep per unit area) can be represented by relating stocking rate to cues perceived in the rangeland environment (e.g. the vegetation type, its range condition, the availability of ground forage) in a multiple regression model. In a person's unique model, the raw score regression weights (B weights) for the cues represent real numbers of sheep per unit change in a cue value. High B weights represent a policy that is responsive to different or changing environmental conditions. Low B weights represent an unresponsive approach to the environment. The mean judgment is a measure of mean stocking rate over a suite of rangeland environmental conditions and a low multiple correlation coefficient (R) represents a low consistency of information use.

In one application (D.G. Burnside, unpubl. report), there was wide variation between individuals' stocking rate judgments, the information they used in judgment and their perception of important rangeland characteristics. The findings suggest an extension focus on the perception of key environmental indicators, and the development of simple decision rules for use in tactical judgments.

**How is the land changing?** Judging change in range condition, using the output from formal rangeland monitoring systems.

Some subjective assessment of ground-based range monitoring sites is an inevitable and necessary part of the process. In a preliminary study, individual's range trend judgments were captured using a hierarchical lens model. The model permitted a separation of judgments of change using photographic and technical data sources, with a subsequent combination of these separate judgments into an overall judgment of range trend. The study revealed relatively low measures for the consistency of range monitoring information usage in judgment, and marked variation between individuals in the relative importance of the data sources. From these findings, recommendations have been made for changes to the means of data presentation, accompanied by training that will encourage a more consistent and meaningful interpretation of rangeland change (Burnside and Faithfull, 1993). These methods and recommendations could be extended to other agricultural situations where subjective assessment of environmental feedback is required.

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#### **OUR RANGELAND NEEDS A WOMAN'S TOUCH**

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#### INTRODUCTION

Currently rangeland management in Australia is in a state of flux with a need to find economically and environmentally sustainable land-use practices able to meet concerns over land degradation, loss of biodiversity, declining terms of trade for some industries, and the social pressure resulting from these changes. Key issues have been circulated for comment (NRMWG 1994). It is important to ensure women are a major part of this process, not only because women make up the majority of the Australian population, but more importantly, because women have valuable attributes and skills which lend themselves to positive action for ecological sustainability generally (Claridge 1993).

#### THE NEED FOR WOMEN

Women have a characteristic way of structuring the world which is different from men, and in cultures of strongly differentiated sex roles, men and women look at different aspects of the environment and acquire different attitudes toward them (Tuan 1974).

Several studies and surveys in recent years have shown that women express more concern for the environment than do men (e.g. MORI 1990). In 1991 the National Women's Consultative Council conducted consultations with 3,000 women. Ninety nine per cent of the women thought environmental issues were very serious, and over a quarter (28%) considered environmental issues to be the most serious issues in the world today. Australians in general have become more concerned with conservation issues in the last fifty years. Morton (1993) considers this to have been bought about by internalisation of values from society and the culture around us. But women's increased visibility in the media and all areas of society has been instrumental in this change.

Holmes (1994) points to the challenges posed by multiple land values, uncertainties in future land use directions (possible multiple use), and diversification in interest groups and policy directions, all occurring in Australia's rangelands. These challenges demand a form of problem solving different from scientific rationalism and based on holistic and intuitive reasoning. Intuitive thinking, is a non-intellectual experience of reality that expands, rather than concentrates, awareness (Mellor 1992). Both attributes are more clearly developed in women.

The Office of the Status of Women (1992) describes women's holistic view as an ability to see all life on earth as interconnected. In this world-view women consider environmental issues as part of an integrated system rather than as isolated problems. Related to this holistic view of the world is the way women view environmental issues - they tend to have a long-term environmental perspective while men have a shorter term economic perspective (MORI 1990, Claridge 1993). These two attributes, long-term perspective and holistic approach, are valuable if not vital ingredients for the strategy which "..should recognise the interrelated nature of the economic (development and adjustment), environmental and social issues and facilitate the integration of conservation and production-orientated management." (NRMWG p2).

# INVOLVEMENT OF WOMEN

Women's attributes and skills make it imperative that they play a major role in the communication and consultation process leading to the rangeland strategy. Yet, stakeholder groups identified by the Working Group do not specifically include women. Under the *Aboriginal Peoples* category women may in fact have very little representation. When calling for input from the community either under the *Pastoralism* or *Community Generally* heading the prevailing male hegemony may result in women's silence. When accessing Landcare and conservation groups it is possible that although women make up the majority of the membership of these groups (Duxbury 1992, House of Representatives Standing Committee 1992), they may not be well represented in the consultation process as this may be aimed at the decision making level of the groups where women are poorly represented (Claridge 1993a).

Women need to be identified as a distinct group in the consultation process. Also within all other identified groups it is necessary to take specific action to ensure women have input into the draft strategy. By taking such a stand the inputs into the national strategy will more truly represent the wishes of the electorate and the large financial inputs necessary for any successful outcome of a national strategy will be possible from both the urban and rural electorates of the nation.

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# CHANGING GRAZING MANAGEMENT ON "KEEN-GEA" - THE STRATEGIES AND FINDINGS - A PRODUCERS EXPERIENCE

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#### **ABSTRACT**

This paper outlines a change of management approach on an extensive beef producing property in North Queensland. Information on the financial performance, beef production and land condition under the two management styles are provided.

# **INTRODUCTION**

"Keen-Gea" is a 19,000 ha cattle property situated 90 km south of Torrens Creek which I run in conjunction with my wife and two children. The 86 year rainfall average is 510 mm. The property is situated on the change between the Forest/Desert country with sandy and duplex soils to the north and east, and the Plains/Blackwood/Gidgee scrubs with black and brown clay soils to the south and west. This variation in land, soil and timber types was one of the reasons why we purchased "Keen-Gea" in 1978. The Queensland Lands Department rate the carrying capacity of the property at 1400 head (1:13.5 ha). Pulling and planting buffel on about 6000 ha of Blackwood (*Acacia argyrodendron*) has increased this safe carrying capacity to 1800-2000 head.

### LAND MANAGEMENT & STOCKING RATES

Like most people during the 80's we ran the property to the limit. At one time we had 3200 head on the place. Our experience with these high stock numbers during the 80's included:-

- I. Selling only an average of 330 head each year (range 84 to 508 head).
- 2. A reasonably high gross income.
- 3. High running costs in the form of wages, extra freight, agents' commission, high lick consumption etc.
- 4. Locking ourselves into the store cattle market and having very few fats.
- 5. Creating a man-made drought for around four years.
- 6. Increased sucker regrowth through not having any fuel for fires.
- 7. High death rates in most years.
- 8. Degradation of pastures including buffel paddocks.
- 9. Having to practice early weaning.
- 10. Financial trouble.

In hindsight, our high stocking had only created bigger problems. Things came to a head in 1989 when we realised that our dwindling stock numbers soon wouldn't cover our rising running costs, due mainly to drought and supplementary feeding. We finally sat down with our bankers and worked out a re-financing package.

Our venture into reduced stocking rates was forced on us by the run of dry years, and bad management, so we had little choice but to make it work. Useful rain in November 1989 and six months grace before the new loan repayments had to be made was the break we needed. With only a limited number of eligible sale cattle the only way we could satisfy the bank was to get the maximum dollars per article sold, in a short period of time.

# RESULTS OF REDUCED STOCKING RATES

By keeping stock numbers around or just under the Lands Department recommendations since 1989 we have achieved:-

- 1. A return to a trading profit on an increasing plane for the last four financial years.
- 2. Cattle in much better health with higher fertility, which seems to be still rising.
- 3. A high weaning percentage and low breeder deaths without feeding any licks to females.

- 4. Turnoff of finished cattle with minimal use of supplements. M8U and meat meal have been used for short periods (up to six weeks) only in poor years to finish a consignment of cattle. Since November '89 we haven't sold any stores only fats of the same turnoff age.
- 5. Greatly reduced running costs.
- 6. Increased pasture yields on the forest country, with a return of black spear grass and kangaroo grass. The black soil grasses hadn't slipped as much, so they came back to full health much more quickly.
- 7. The reality of off-property investment.

With lower running costs and a reduced work load, we have only needed to sell around 270 head of cattle per year to meet all running costs. Our average price over the last four years has been \$433 per head. Females are culled on type and constitution first, then the ones that are to go with bulls are joined as weaners with weaner bulls. These heifers must wean a suitable type of calf during their second year, or they are culled. Heifers which are either culled or surplus to requirement, are sold to the local trade or Korean market as milk or two tooth, 200 kg D.W. and 10 mm fat cover. The older breeders are on a similar timetable. Steers are only fattened once, and then they are sold. An average steer is around 30 months with 4 teeth and a dressed weight of about 260 kg with 10 mm of fat.

Another important result is that we don't have to practice early weaning in order to get calves. Provide ample grazing for the mother and she will grow the calf a lot better than we can with purchased feed. We have never produced a 4 or 6 tooth Jap ox from early weaned calves, but we have achieved this quite often with 5-6 month old weaned calves. The sisters of these steers, because they are better grown, breed at a younger age, with the lead of these heifers starting to calve before they are two years old.

#### **FUTURE STRATEGIES**

In the past we have spelled paddocks for a year or so with good results. Some areas of claypans have started to regrass without any input from us, and all paddocks have grassed up well. However locking up a paddock still leaves us one paddock short when we use this strategy. Unless stock numbers are reduced to compensate, other areas must then be over stocked.

In 1993 we tried a new strategy of stocking two paddocks at 75% of their safe rate to overcome this problem. The results have been most interesting:-

- \* A calving rate among maiden heifers of over 100% (49 out of 49 by December 1993) with 6% bulls.
- \* Dry cows in fat score 3/4 condition and still cycling at the end of October. A mob of these cows were artificially inseminated during the last week of October.

These two paddocks did not received any more than 240 mm of rain in the period June '92 to October '93 and the females did not have access to any lick. The paddocks still had ample fuel to carry a fire to control suckers, if needed. There would have been much more grass in a good season. As regrowth is reduced by fire and grass competition, the stock numbers may then be increased accordingly.

The marketing edge of this strategy is that with running costs reduced, cattle and pastures in good health, and being only 75% stocked, there will always be ready feed and room if a stock deal comes along.

In an attempt to even out the grazing pressures in all paddocks on "Keen-Gea" we plan to relocate some fences. At present, some forest paddocks have corners or sides of softer blackwood country which are grazed so heavily that they are turning into claypans. In blackwood paddocks, stock need access to a small area of forest so they can get out of the water during the wet. These small areas of forest are never overgrazed because as soon as the black soil grasses come away the stock only lightly graze or camp in the forest country. I have purchased a Landsat TM photo of "Keen-Gea" which I find useful to identify claypan areas, and plan paddock layouts. I can then go into the area with a plan rather than riding around for hours.

# CONCLUSION

One beef producer in the district told me recently that "They are dying like flies over here", but then in the next breath, "You have been lucky at 'Keen-Gea' seeing that you still have a lot of grass left, it is obvious that you must have had a lot more rain than anybody else". When neighbours make statements like this, I feel that we must be starting to do something right.

# GIVING A SPATIAL DIMENSION TO RISK ASSESSMENT IN RANGELANDS RESOURCE MANAGEMENT

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#### **ABSTRACT**

The management of the rangeland resource for beef production involves the land manager making management decisions in a spatially variable and highly uncertain context. The decision maker needs to evaluate a number of risks. These include climatic, environmental, production and economic risks. Such risks may not be expressed uniformly across the landscape or over time. This paper describes a tool for examining the effects of grazing management strategies in terms of the risks to vegetation state and to pasture and animal production.

### INTRODUCTION

The natural resource base (e.g. landform, soils, vegetation) is typically variable within a grazing management unit (e.g. paddock). For example, some parts of a management unit may be more productive than others in terms of pasture production (e.g. dry matter yield) than others. Some areas may also be unattractive or inaccessible to grazing animals because of, for example, distance to water, pasture species composition or seasonal conditions. The total amount of available edible feed within a management unit will therefore vary according to these factors. Consequently, under a given management strategy (e.g. stocking rate, fire frequency) the level of utilisation, and hence the impact of grazing on the natural resource base, will vary from one area to another within a management unit as well as between management units.

# THE LANDASSESS DECISION SUPPORT SYSTEM

Landassess DSS (Bellamy et al. 1993) is a prototype PC-based computerised decision support system (DSS) which integrates a geographic information system (GIS), a resource database and scientific and economic models. It allows the user to assess the spatial variability in the natural resource base and pasture production within and between management units. The user may, by applying alternative management scenarios, assess the risks of change to the vegetation and soil state, and also evaluate associated productivity changes and consequent economic effects. It is currently being developed for the pasture lands and systems of the Katherine-Daly Basin region of the Northern Territory.

# **RISK ASSESSMENT**

The framework used by Landassess DSS for the assessment of the current vegetation state and the risks of vegetation change from grazing management and other factors is the state-transition model proposed by Westoby *et al.* (1989). In Landassess DSS, state-transition models are knowledge based models (i.e. they comprise rule-based expert/heuristic knowledge relating to the interaction between vegetation state, forage production, utilisation rate, animal behaviour and the natural resource base). By integrating models of vegetation change with a water balance model and a GIS and associated database of the natural resource base, Landassess DSS is able to take account of the spatial variation in vegetation response to grazing management for beef production. The integration of models within a GIS framework provides the capability for the user to:

- (i) visualise the likely change in state of the vegetation and the soil resource within a management unit, given the imposition of a particular management scenario over a defined time period
- (ii) visualise the spatial variability in forage utilisation patterns through the linking of outcomes of management scenarios to models of pasture and animal production (J.G. McIvor and A. J. Ash, *pers comm.*)
- (iii) evaluate consequences of the change in state in terms of the expected change in pasture yield and animal production (i.e. live weight gain) and to assess the economic consequences (i.e. gross margins) at an aggregated management unit level.

For example, the user may apply a high level of utilisation (e.g. > 60%) to a paddock over a particular time period, say 5 years. Landassess DSS will then show the likely changes in vegetation state and corresponding changes in pasture and animal production (Fig. 1).

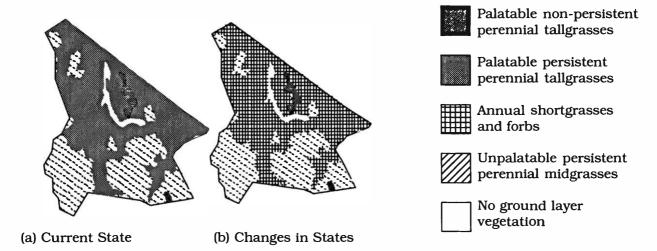


Fig. 1. Changes in the spatial variability of vegetation state within a paddock due to high utilisation over 5 years. The table shows changes in annual total and available pasture yield, and live weight gain.

Annual Production (total area 40 sq. km.)	(a)	(b)
Total pasture yield per paddock (tonnes) Available pasture yield per paddock (tonnes) LWG per paddock (kg) (at stocking rate of 3AE/sq. km.)	3527 2555 11238	2267 1295 2177

### **DISCUSSION**

Landassess DSS provides a tool for assessing the spatial variability in the state of a grazing management unit, such as a paddock, and a capability for evaluating the impact of alternate management strategies. By linking the outcomes of models of change in vegetation and soil state to models of pasture and animal production, and economic production, Landassess DSS allows the user to evaluate and compare management options in terms of the risks to the sustainability of the resource base and to the profitability of production.

# ACKNOWLEDGEMENTS.

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# FLUCTUATING FORTUNES OF LONG TERM PRODUCERS IN WESTERN QLD

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# **ABSTRACT**

In this paper the results from an economic study of seven producers over 22 years are presented. Issues related to the profitability of these properties over time were examined.

Results for this group of producers indicated that they had been able to partially counter the declining terms of trade. Average profit at full equity was 5.7% of assets but was 4% with the highest performing producer excluded. The internal rate of return for the total investment in grazing was 3.8%.

Profit at full equity followed 6-8 year cycles, but 55% of the profit realised was realised in 22% of the years studied.

#### INTRODUCTION

Data were collected from a sample of seven producers on the mitchell grass downs around McKinlay and Julia Creek covering a period of 22 years from 1969/70 to 1990/91.

The key objectives of this study were: to examine profitability of grazing between years, between properties and over time and; review adjustments producers have made in response to market conditions.

# RESULTS AND DISCUSSION

A summary of key performance measures for properties in the study is shown in Table 1.

# Property size and enterprise composition

Average property size ranged from 11000 to 26000 hectares (6000 to 16000 DSE's). About 60% of the carrying capacity consisted of 40% cattle but these proportions varied over time with markets and seasons.

# Cost structure

Total costs (cash expenses, depreciation and imputed labour) per \$100 output averaged \$76 per property with a range between properties from \$60 to \$90. Over time, costs per \$100 output ranged from \$50 in the 1973 wool 'boom' to \$125 during the 1970 wool 'crash' but was close to average in 50% of years.

Producers exhibited an ability to reduce costs by up to a third from the previous medium term average in response to a market downturn with compensatory expenditure increases when conditions improved.

# **Profitability**

Profit at full equity averaged \$50000 with a range from \$8500 to \$141000. This represented a rate of return of 5.7% on assets with a range from 1.7% to 11%. With the highest performing property omitted, profit at full equity was \$36000 or 4% of assets. Profit at full equity as a proportion of assets and on a per hectare basis was positively correlated with property size.

Profit at full equity exhibited significant fluctuations over time and tended to move in 6-8 year cycles. Five large profit years (22% of years) accounted for 55% of the profit.

The internal rate of return, which included movements in land values, was 3.8% with a range from 1.7% to 12%. This result is interpreted as follows: 'If an average producer had invested in the property on a walk-in/walk-out basis in 1969, managed it for the 22 year period and sold in 1991, then a 3.8% real rate of return on that investment would have been realised'.

# Gross margins

There was little difference between average sheep and cattle gross margins on a per dry sheep equivalent basis over the study period. There were unquantified effects from intergrazing both sheep and cattle in terms of pasture utilisation and diversification to reduce price risk. There was no period during the study when both enterprises were yielding poor returns at the same time.

#### **Trends**

Profit at full equity exhibited a relatively stable trend, despite the terms of trade movement against these producers. It was estimated that output needed to increase on average by 2.4% per annum (\$4630) per property to cover the movement in wool and cattle prices against grazing businesses. Adjustments in enterprise mix in response to market and seasonal conditions, cost management to suit market condition, improved management and/or timely expansion of property size were factors considered to be key reasons why these producers were able to partly offset the declining terms of trade.

Table 1. Summary of results for study properties (average 1969/70-1990/91)

Measure calculated	Average	Range
Property carrying capacity (DSE)	10600	6300 - 17000
Sheep number	6500	4300 - 8800
Cattle number	500	227 - 1100
Cash expenses (\$/\$100 output)	59	45 - 75
Total costs (\$/\$100 output)	75	60 - 90
Profit at full equity (\$)	50000	8600 - 141401
Profit at full equity (% assets)	5.7	1.7 - 11
Internal rate of return (%)	3.8	1.7 - 12
Sheep gross margin (\$/sheep)	15	12 - 17
Cattle gross margin (\$/beast)	105	86 - 135

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## ECONOMIC FOOD PLANTS OF WESTERN QUEENSLAND

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#### SUMMARY

Case studies from the 1993/94 harvest of wild limes and native thyme are presented as examples of economic food plants of western Queensland. The demand for bush foods is expected to increase dramatically, which represents a unique opportunity for Australia's rangelands in the wild harvest and establishment of commercial plantations of native food plants.

#### INTRODUCTION

Many plants within western Queensland have commercial potential in the Australian native food industry. They range from trees, shrubs and vines with edible fruits and seeds to plants with strongly scented leaves suitable for use as herbs and seasonings. Interest in the wild harvest of these plants is relatively small at present, but promises to grow rapidly over the next 2 to 5 years. The potential to establish plantations of native food plants is also strong. We wish to present two case studies to promote discussion and to facilitate the recognition of this new industry as having an important role in the future of Australia's rangelands.

#### **ECONOMIC FOOD PLANTS**

Plants with commercial value, or potential commercial value (Table 1) require a number of traits. The plants must be native, bear an edible portion with a distinctive flavour, need minimal processing and be readily transportable. Transport is of particular concern in Australia's rangelands as the existing infrastructure is often inadequate for the shipping of perishables.

Table 1.	Some	rangeland	plants	with	commercial	food	value.

Common Name	Growth Form	Edible Portion	Time of Harvest	Current Value(\$/kg)
Bottletree	tree	seed	mid-late	20
Bush Banana	vine	fruit	summer	N/A
<b>Bush Tomato</b>	annual/perennial	berry	summer	N/A
Emu Apple	tree	fruit	summer	N/A
Native Thyme	perennial bush	leaf	summer	55
Wattles	tree	seed	summer	5
Wild Lime	tree	fruit	early	8
Wild Orange	tree	fruit	mid-late summe	r 5

Of the plants listed above, two have been chosen as examples of the current state of wild food harvest in western Queensland.

## Wild Limes

The wild lime (*Eremocitrus glauca*) is more often regarded as a woody weed by graziers. It is a small shrub, growing up to 2.5m tall when mature. Over the 1993/94 summer a total of 260kg of wild lime fruit was harvested from stands of existing trees in the Tambo district. The harvest was on two separate properties, predominantly from cleared gidyea country. The harvest was only a small proportion of the total crop, but represents a return of \$2080. Labour inputs were 2-4 pickers for 2-3 days harvesting. Up to 3000kg of fruit is expected to be harvested over the 1994/95 summer from the same area, with a net return of \$24,000. This will require a labour input of 4-6 people for 1-2 weeks.

## **Native Thyme**

Native thyme (*Ocimum* spp) is a small perennial shrub (0.5m high) with purple flowers. It bears a close resemblance to basil, and grows predominantly in natural clearings in gidyea country. A total of 60kg of wild thyme was harvested from one property in the Longreach district following summer rains. This represents a return of \$4800. A harvest of up to 200kg per season should be possible, with 2-3 weeks harvesting for 2-3 people required. The potential return would be approximately \$11,000.

Both of these potential harvests also represent the upper limit of the market at present. The scope for a large number of pickers to become involved in the wild harvest of individual products is therefore limited. There is scope for the supply of other products, and the market is rapidly expanding.

## THE BUSH FOOD MARKET

Bush foods are served in 400 restaurants around Australia, as well as in Qantas first and business class. There is also an expanding market in gourmet food manufacture, which includes wattleseed ice cream (a gold medal winner at the Royal Easter Show in Sydney), jams and chutneys. All indications are that demand will increase up to, and beyond, the Sydney Olympics in the year 2000. This event should prove to be of major significance to the bush food industry which is very well suited to the theme of Sydney's "green" Olympics.

Regularity of supply is a major problem for the bush food industry of western Queensland. This is primarily due to the irregularity of rainfall which is typical of rangeland systems. One solution is supplementary watering in plantations of locally native vegetation. Bush food plantations would also add to the narrow economic base of rangeland enterprises and help contribute to Australia's "green" image. The current market may only be able to support the wild harvest of produce, but the potential scope of this industry is immense.

#### DUST AND DOLLARS: DROUGHT MANAGEMENT IN AUSTRALIA

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#### **ABSTRACT**

An industry survey throughout the rangelands in 1992 defined the management strategies and tactics which pastoralists use to cope with climatic variability. The feasibility of the different options varied between regions in some systematic ways, in relation to patterns of resources, access and markets, and socio-political factors. Producers identified information which might help their decision-making, including better indicators and benchmarks tailored to regional conditions. Best practices must be defined in relation to these regional differences.

#### INTRODUCTION

In 1992-1993, we visited over 130 properties throughout the rangelands, as well as most regional agency offices, and communicated with about another 100 people about management approaches to handling climatic variability. With the assistance of a workshop which brought together people from most major rangeland regions, the results of this survey are now being published in three reports, with some supporting spreadsheet software. The reports document what people do in different areas, how these things vary across the nation, and what information producers felt would help them cope with drought management better. This paper summarises some key findings.

## **OPTIONS OPEN TO MANAGERS**

The major categories of options are shown in the Table (more details in Stafford Smith 1994). Most importantly, some items (in italics, plus many diversification options) are strategic, requiring long-term planning and preparation, while others are tactical (actions once a drought arrives). There was also a surprising number of different options for diversification around the country. Although many were only appropriate for specific conditions, together they add up to a formidable array of options.

Manage cash-flow		Cash reserves	IEDs, etc.
	,	Income smoothing	Tax measures, Futures
		Investments	Real estate, Stocks
Manage livestock	Match numbers to feed (or water)	Off-property (post-drought)	Sell, Agist, Move Buy, Take agistment
		On-property	Shoot, Control mating, Low stocking rates
	Match feed to numbers	Improve forage Feed in paddock Feed centrally	Pasture, Paddock design Cut feed, Supplements Feedlot, Cultivation
	Match water supply to numbers	On-property	Water-cart, Open new waters
Diversify	Diversify on-farm  Diversify off-farm	Animals Plants People Other Land-based	Goat, Roos, Emu, Yabbies Natives, Crops, Fruit Recreation, Tourism Conservation Management, Equipment
Do nothing		Other employment	Wide variety, skill-depn

For many of these options, it was possible to identify the factors which determined whether or not they were feasible in an area, and then whether it was worth the while of individuals to pursue them.

## **GEOGRAPHIC VARIATION**

The extent to which different management options were feasible varied from region to region and property to property. Some variations were predictable and linked to resources or markets; other were less predictable, related to social conditions and communications. Three general categories of causes for variation were:

- \* climate and resource-based: for example, in northern Australia, summer dominant rains meant different types of decision points and reliability than in aseasonal areas of western NSW; similarly, low stocking rate options may be more feasible where vegetation types are perennial and persistent (e.g. saltbush or Mitchell grass);
- \* access and market-oriented: regions vary from 100 to over 1000 km from markets and from sources of fodder; this affects how easily stock can be sold in dry times, and the economic feasibility of buying in feed;
- \* socio-political and cultural: there are state differences in laws, some areas have a greater involvement in Land Care, communications like television and STD phones have different histories in different regions.

Diagrams of some of these patterns may be seen on the poster display.

#### **COMPARING OPTIONS**

Comparing tactical options once a drought has started should be reasonably easy (another poster [Hope 1994] at this meeting displays some approaches to this), although it is difficult to account for the longer term impacts of different measures. Pastoralists particularly noted the need to know more about the effects of re-stocking after a drought. Comparing strategic options is harder, since complex interactions between stocking rate and fluctuations in stock numbers come into play, as well as other long-term considerations. Some of these problems are being addressed in a new LWRRDC/MRC/WRDC-funded joint CSIRO-QDPI project, *DroughtPlan*. Producers also noted the need for better indicators of production performance and ecological state, which were locally-based, and which they themselves could use for adaptive management. These must take account of the levels of resilience of different pastures.

#### **IMPLICATIONS**

Better management for drought and climatic variability is an essential part of maintaining a sustainable and viable pastoral industry where it is appropriate. The ways in which this might be achieved vary hugely across the continent, often in predictable ways. In developing a National Strategy for Rangeland Management it is vital that these regional differences are recognised. Regions in which it is feasible to cope with climatic variability and remain viable will retain a pastoral industry with the necessary checks and balances. In regions where this is not feasible, society must be clear about setting other appropriate goals for land use which do not mislead future investors in the pastoral industry.

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## BEST MANAGEMENT PRACTICE IN KINGOONYA SOIL CONSERVATION DISTRICT

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## **ABSTRACT**

All pastoral leases within the Kingoonya Soil Conservation District were assessed for land condition and factors that affect the land's capacity for carrying stock. Management practices between leases varied depending on land type and permanency of water supplies. Best management practices for chenopod shrubland areas have been known for over a 100 years, but have not been applied in some areas.

#### INTRODUCTION

A requirement of the Pastoral Land Management and Conservation Act 1989 is for an assessment of the condition of the land and the land's capacity to carry stock for all pastoral leases by 1998. This task involves assessing 430,000 km² of country of various land types, covering 326 individual leases. The process is conducted on a Soil Conservation District (SCD) basis (Soil Conservation and Land Care Act 1989) and the first district to be assessed was Kingoonya Soil Conservation District. The district covers 69,160 km² comprises 39 leases which are amalgamated into 24 properties. Land types include mulga sand plains, saltbush stony tablelands and pearl bluebush/saltbush plains. Average rainfall ranges from 150 to 200mm.

## **METHODS**

A total of 897 paddocks were inspected and information on land condition and factors that limit the land's capacity to carry stock were identified. This information included water points, fencelines, stock numbers per paddock and different management practices that reflected the different pasture types and management objectives. Overall land condition for each lease was determined by the "Weighted Average Condition Index" method (Tynan *et al.* 1992) which involves a restricted random sample approach. GIS (ARC/INFO) was used to calculate watered areas (WA) based on a 5 km radius around each water for sheep and 8km for cattle, terminating at fencelines.

#### **RESULTS**

Only 57% of the district is within the calculated watered area grazing zone. This results in doubling the average stocking rates (sheep/km²) for several leases in the District when the available watered area (WA) is used as the basis for calculation rather than the total lease area (TLA). The WA gives a more meaningful comparison of stocking rates between leases. However, direct relationships between average stocking rates (previous 10 years) and the assessed land condition on a lease basis were not apparent as land condition is determined by many factors which include; water point location, type of stock, grazing period, season of use, past grazing history, fire disturbance, and other herbivore impact.

The assessment process identified characteristic management practices of leases in good and poor condition.

Management practices characteristic of leases in good condition:

- \* small areas denuded of perennial bush around waters (less than 50m radius)
- spelling portions of the country in good years to permit recruitment of palatable species
- \* small dams to spread grazing pressure in good seasons
- generally waters were not permanent being predominantly dams which resulted in forced spelling of country in a drought; or if permanent waters, these were centrally placed; or low stock numbers on fenceline waters
- \* large portions of paddocks outside the normal summer grazing range of stock (5km) provide winter grazing and wildlife habitat
- management focused on condition of country

Management practices characteristic of leases in poor condition:

- past history of high stock numbers on old waters
- \* high numbers of stock on waters compared with district average
- \* high total grazing pressure from wild, feral and domestic herbivores
- \* set stocking without a spelling policy in good, as well as poor, seasons
- \* waters on southern fencelines or in paddock corners which concentrate grazing pressure
- \* inappropriate timing of grazing e.g. stocking up after first rains following a drought
- \* permanent water supplies that permitted stocking for a longer period into a drought
- \* high rabbit impact on perennial shrubs
- \* inappropriate management of areas previously burnt
- \* stocking country that is susceptible to damage (low resilience)
- management focused on condition of stock

Many of these management practices were identified over 100 years ago, as evidenced in the 1898 and 1927 Royal Commissions into the Pastoral Industry in South Australia.

## CONCLUSION

Relationships between total stock numbers and overall lease condition are determined by many factors which include watered areas, permanency of waters, grazing strategies and management objectives. Comparison of stocking rates between leases should be based on the watered area (WA) rather than the total lease area (TLA). Properties with the same stocking rates may use different stocking strategies. This information will contribute to developing a District Plan for the area that aims to promote sustainable resource use.

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## THE EFFECT OF LAND DEGRADATION ON LAND VALUES

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## INTRODUCTION

Rural land values reflect many factors, but land degradation is being given more recognition. Known "hot spots" exist across Australia where land values and "saleability" are affected by land condition. Also lending institutions are paying greater attention to land degradation when making lending assessments.

There is clear evidence of this in the Western Division (W.D.) in the Ford's Bridge, Coolabah-Byrock, and Cobar areas, with constantly evolving ownership due to small property size and severe woody weed infestations resulting in an up to 50-75% reduction in land values. In comparison, other areas have seen declines of 30-60% in land values due to drought and very low wool prices.

## WHAT HAS BEEN HAPPENING TO W.D. BROADACRE SALES (1990-1993)?

Table 1

Year	Sales	Build-Up	MIP	Average Price (ha)
1991 1992 1993	27 58 80	11 (40%) 13 (22%) 18 (23%)	4 (7%) 11 (14%)	\$21.00 \$19.53 \$18.61

## In What Counties Have Large Numbers of Sales Occurred (1985-1993)

Table 2.

County	Sales	Repeat Sales	MIP
Blaxland	23	4	3
Cowper	45	10	6
Finch	53	-	1
Culgoa	24	2	-
Gunderbooka	20	2	3
Franklin	20	-	3
Irrara	20	2	3
Narran	27	4	-

Note: There are 46 counties in the W.D.

What Has Happened in the Ford's Bridge, Byrock-Coolabah and Cobar Areas (Known "hot-spots").

Table 3

County	1990	1991	1992	1993	Total
Cowper	3	7	6	9	25
Irrara	-	3	5	4	12
Canbelego	1	1	-	1	3
Gunderbooka	3	-	1	7	11

Table 4. Prices per ha of sales (1993) for Counties Cowper, Irrara and Gunderbooka.

County	Property Size (ha)	Price (\$/ha)	Comments
Cowper	20,194	5.94	
•	12,513	9.98	
	11,325	74.97	Irrigation & abattoir MIP
	13,708	14.22	_
	33,889	5.00	
	29,250	2.37	
	17,034	12.00	River frontage
	23,987	4.16	_
Irrara	24,730	10.71	MIP
	16,874	7.11	
	15,271	9.82	
	11,240	13.79	
Gunderbooka	11,266	6.03	MIP
	12,949	42.00	River frontage
	12,016	37.06	<u> </u>
	12,352	6.08	MIP
	9,402	4.78	
	11,520	15.62	
	26,245	6.18	MIP

## **SUMMARY**

As can be seen, the sales occurring in this area:

- 1. are well down on the W.D. average sale price per ha
- 2. have a higher incidence of repeat sales
- 3. have a higher incidence of MIP sales, and although not shown, a significantly higher number of forced sales.

## EXTENSION, EDUCATION AND LANDCARE

(Poster Group Seven)

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## MIDDLEBACK FIELD CENTRE: A BASE FOR RANGELANDS TEACHING AND RESEARCH IN ARID AUSTRALIA

M.H. Andrew, A.D. Nicolson & D.F. Coleman

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#### **ABSTRACT**

Middleback Field Centre is an excellent venue for rangelands teaching, research, meetings and study leave, and it is available for use by rangelands people worldwide. Located on a working sheep station and conveniently near Whyalla, SA, it comprises laboratory facilities, lecture/study area, field barn, visitors apartment and good quality "shearers" accommodation for 30-40 people.

Much of the Australian research into chenopod shrublands has been conducted there over the last 25 years by Dr R.T. Lange and his students, and exciting opportunities remain to be explored.

The new Board of Management is keen to have this Centre used to its full potential. Interested persons should contact the authors for further details.

## MIDDLEBACK FIELD CENTRE: HISTORY AND FACILITIES

Middleback has provided a base for senior undergraduate/graduate teaching and research in rangelands for nearly 25 years, under the auspices of Dr R.T. Lange (now retired) within The University of Adelaide. This program has been a major source of rangelands and ecological training in Australia. Former Lange students can be found all over Australia in a range of agencies and roles, and Middleback itself has been and remains a major venue for research into chenopod shrublands.

The Middleback program developed from humble beginnings. Middleback Station and associated leases possess some of the best range condition in SA, and has water points located independently of topography. Thus Middleback provided an excellent context for studying the piosphere (waterpoint) phenomenon. It also provided an excellent location for undergraduate teaching, based out of the shearers quarters, because of Middleback's proximity to the city of Whyalla (16 km West), and its associated good transport links (road, bus, plane and rail). Its location is still a major attraction.

Over the last 15 years, a major new facility has been constructed and the shearers quarters renovated, to provide lecture room, laboratory, field barn, distinguished visitor's apartment and accommodation for about 40 people. It is now an excellent facility which should be utilised much more for the good of the rangeland profession.

## **TEACHING AND RESEARCH**

For nearly 25 years, Dr Lange (of The University of Adelaide's Botany Department) taught a final year BSc degree subject "Rangeland Ecology", intensively in January, out of the Botany Department. For the last five years, he (and now Dr Andrew) has taught a very similar subject based from the Roseworthy Campus.

The hallmarks of this teaching have been:

- intensive teaching in residence at Middleback for short (7-12 day) periods
- location on a commercial sheep station which becomes a living laboratory to reinforce lecture material
- location in one of the best-managed sheep stations, with low stocking rates and rangeland in excellent condition
- a curriculum which ranges widely over rangeland ecology and management issues including, in addition to the sciences, legislation, administration, station management, economics and politics

- lectures by the station owner/managers, and other professionals involved in pastoral management/administration
- hands-on experiential learning by students in individual, group and class projects which are inherently interdisciplinary
- a focus on sustainable development of the arid rangelands, emphasising the impact of vertebrate herbivores (sheep, kangaroos, rabbits) on the rangeland vegetation.
- an evolving curriculum which reflects current research interests of staff and graduate students.

This format and real-world context have proved enormously popular with students, who commonly claim this subject to be the highlight of their University course. From this foundation, Dr Lange developed several graduate level rangeland subjects for the Arts Faculty. Graduate rangelands course work in Natural Resources will commence in 1995.

The Centre is also used for TAFE and industry courses, (including the annual Plant Identification Course for pastoralists, sponsored by the SA Branch of the Australian Rangelands Society).

The Centre also hosts an annual seminar weekend on a topical rangelands theme, or to feature a leading rangelands speaker; other organisations use it as a venue for meetings from time to time.

## **OPPORTUNITIES**

There are numerous research opportunities afforded by the Centre's location not just on a working sheep station and near the homestead, but also by its careful construction within a fenced-off myall-over-chenopod woodland in good condition which allows for instrumented access for ecophysiological studies.

Staff and student research programs currently include: plant demography, especially of the long-lived perennials such as the Western myall tree *Acacia papyrocarpa*; seed ecology including predation by ants; grazing ecology/diet selection; native fauna (the largest known population of the rare and recently described tiny marsupial carnivore *Ningaui yvonnii* occurs nearby); below-ground processes; and remote sensing.

For information about courses available, possibilities for graduate research, opportunities for visiting researchers, and availability for meetings and retreats, please contact the authors.

Since -1993, following the retirement of Dr R.T. Lange, the management of the Centre has been overseen by a Board of Management comprising University, Government and Pastoralist members. At the time of writing, an Administrative Director is being sought to oversee and promote the Centre's use.

## FINANCIAL BUSINESS MANAGEMENT IN THE RANGELANDS OF NEW SOUTH WALES

L.W. Beer

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Lack of understanding, training and skills in financial management have all been identified as real issues for rural producers Australia wide. Producers themselves are the ones who are realising the need to sharpen up their skills. In some instances this realisation has been prompted by the cost/price squeeze or particular demands from agribusiness or by the increasing complexity of rural production as a business.

It is well to note that "It is planned that the outcomes of this Conference will contribute to developing guidelines for best practice in rangeland management". It is also important to note that the theme of "CLEAN COUNTRY, CLEAN PRODUCT, CLEAR PROFIT" includes the all important reference to the need to assess everything we do in dollar (\$) terms as well as physical terms.

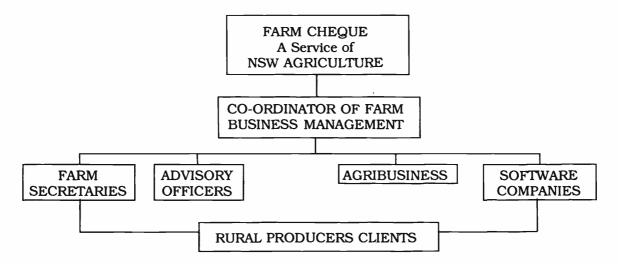
The financial management ability of producers and property managers in the rangeland area of New South Wales is neither worse nor better than that of other producers in the country. One of the real problems in western New South Wales is lack of access to opportunity. The opportunity for training in financial management; the opportunity for the development of skills and the continuing up date of those skills; the opportunity to access new information and new technology; and sometimes, the chance to share ideas with others in similar production programs and with similar limitations.

New South Wales has a service which provides for a variety of training opportunities for producers to develop their understanding and skills in farm financial management. It is a unique service which is highly developed in the southern part of the State and of particular interest to this conference - as it services the rangelands in the south-western area of New South Wales.

The service is centred on a computerised physical and financial farm management package and caters for a wide range of people with varying degrees of knowledge, experience and expectations.

The FARM Cheque service, as it is called, can best be described by firstly looking at how it is structured and then by examining the various phases of the service.

#### **STRATEGIES**



The FARM Cheque service provides the basis for the financial management component of the Property Management Planning and Drought Related Education and Training Program, in New South Wales called "Farming For the Future". The service provides access to opportunity for people in the rangelands area through a number of activities which are briefly described.

#### **AWARENESS**

There are constant reminders that producers are not always aware of the services and opportunities available to them. Either through the media or when producers meet as groups, information is provided on:

- + Advisory services
- + 008 telephone numbers
- + Rural Assistance measures
- + The Country Guide
- + Workshops on offer

- + Home Study programs
- + Rural women's network
- + Computer software guides
- + Rural Financial Counsellors
- + FARM Cheque secretarial service

Agribusiness and Agency staff are also targeted in developing awareness of the service.

#### BASIC FINANCIAL WORKSHOPS

These workshops are the second phase. A needs analysis conducted early in the 1990's highlighted the fact that basic financial management skills were an area requiring considerable attention amongst the rural producers of New South Wales. A series of workshops have been conducted in the southern area, including the rangelands of the south west. Some 2000 producers have attended these workshops in the past 3 years and the service continues to be offered on a needs basis. The basic topics on offer include:

- + Keeping Financial Records
- + Cash Flow Budgeting

+ Enterprise Planning

+ Borrowing and Cash Management

Workshops on other topics will be developed as clients identify a need through their involvement in the "Farming For the Future" program.

## FARM CHEQUE FINANCIAL MANAGEMENT SERVICE

This third phase is for non-computer owners and involves the secretary entering the producer's financial information on to the computer and providing regular and relevant financial reports back to the producer. Assistance is also given in developing cashflow budgets and providing a monthly budget versus actual report. The service helps producers to:

- + Determine the financial state of their business
- + Gain financial control
- + Make better use of professional services
- + Gain a better understanding of computers

## FARM CHEQUE FINANCIAL MANAGEMENT SERVICE

This service is provided to those who own a computer. Producers who choose to purchase Phoenix software can make use of the secretary to set up the program and arrange the standard enterprise headings. There is also a support network available for those who have difficulty. Producers using this service also utilise the workshops which are available.

## **COMPUTER WORKSHOPS**

Computer workshops are the fifth phase in the service. They are aimed at both those producers who are deciding whether to purchase a computer, and those who have purchased one and now find they have many questions to be answered. Topics for the workshop include:

- + Financial Management using a computer
- + Mastering Phoenix
- + Cashbook by computer
- + Enterprise reports for livestock
- + Spreadsheets
- + Enterprise reports for crops
- + Profit and balance sheets

## COMPARATIVE ANALYSIS

This final phase of the FARM Cheque program is utilised by about one third of the members involved in phases three and four. This information is providing benchmark figures for members and for NSW Agriculture staff who use it as a basis for discussions with FARM Cheque member groups.

# INFOTOOL - SUPPLYING INFORMATION FOR PROPERTY MANAGEMENT PLANNING IN QUEENSLAND

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#### **ABSTRACT**

The computer package, INFOTOOL, provides a source of integrated information for those involved in land management and land use in Queensland. Its strength lies in its flexibility and portability and, as such, is providing a vital support for extension services to the Property Management Planning (PMP) environment across Queensland. Although developed initially for the PMP environment, the package has wider potential for application, including Landcare groups, DPI Information centres, schools and community resource centres. It has been supplied to over 90% of the staff in the Land Conservation section of the Queensland Department of Primary Industries.

#### INTRODUCTION

Information and decision support are increasingly important components of extension activities in the 1990's. Property Management Planning (PMP) is no exception. In Queensland there is a large and growing range of extension materials and information resources appropriate to PMP activities. The problem for extension staff is coping with the ever-increasing supply of information from many sources and meeting the demand from clients for relevant, up-to-date and easily assimilated information.

#### INFOTOOL

INFOTOOL integrates the client-orientated land management/production/use information for Queensland, generated by the Queensland Government and other authorities. It constitutes a readily available tool with which to search for appropriate information resources by scanning large bibliographies. INFOTOOL uses database technology, and will operate on any IBM compatible personal computer. The user interface is easy to use and provides full searching functionality. The INFOTOOL computer package was written in association with regional and district Land Conservation extension staff.

INFOTOOL contains four bibliographies. Three of these allow the user to search for information resources (publications and video) to support their extension processes and information needs. The fourth bibliography is designed for the user to enter information resources identified from other sources.

## DISCUSSION

The Property Planning process has been evolving at a rapid rate, especially that area involving access to information. Allied to this is an overall reduction in the public sector of resources to extension services coinciding with increased demand by clients for specific services. This is forcing extension officers working in the PMP area to develop and use appropriate skills and tools. The ability to supply information that is comprehensive, pertinent to client's needs, and up-to-date has become critical for extension staff involved in PMP.

In Queensland, extension staff had limited access to such information. Constraints included poor access to catalogues and searching facilities, limited physical access to the resources, and poor marketing of the available information resources.

INFOTOOL was designed to overcome these constraints. It enhances the use of the existing information resources by improving the exposure of extension staff to the information resources available. When the user takes advantage of the portability of a lap-top computer, INFOTOOL becomes an even more powerful information management and dissemination tool.

The PMP process is, by definition, multi-disciplinary. INFOTOOL supports this by identifying

information sources which help to encompass the complexity and breadth of disciplinary skills required to achieve PMP objectives.

Through extension staff, client exposure to the available up-to-date information resources will increase, enabling property managers to develop a more complete appraisal of the implications of a particular decision. Managers will then be able to integrate the knowledge gained with their own prior knowledge and values to develop appropriate options. This helps to foster ownership and the adoption of the selected strategy.

Extension staff were consulted regularly during the development of INFOTOOL. The result is a practical and useful extension support tool for PMP. INFOTOOL has also been identified by extension staff as having the potential to make a significant impact on the extension areas shown in Table 1. There is a large group of potential users of INFOTOOL including public libraries, schools, Landcare groups, community resource centres and DPI information centres. INFOTOOL usage by these users could certainly increase the demand on the available information resources.

Table 1. Extension areas where INFOTOOL has the potential for a significant impact.

Extension area (which could benefit)	Actual impacts identified
1. Source of technical information	<ul><li>* information availability</li><li>* own bibliography capability</li><li>* background information</li></ul>
2. Farm business management workshops	* information support/gathering
3. PMP workshops	<ul> <li>* pre-workshop information gathering</li> <li>* specific enquiries during workshops</li> <li>* post-workshop information supply</li> <li>* effective library access</li> </ul>
4. Extension support	* on property; in office; research; identification of information gaps; field days; front counter (ad hoc) enquiries educational (school) enquiries * multi-disciplinary information support

## CONCLUSION

INFOTOOL is becoming a part of Queensland's PMP strategy as extension staff integrate the package into their operational processes. The software supports the supply and dissemination of information into the PMP environment, enabling extension staff to deliver comprehensive, pertinent and up-to-date information to the client. It also has the potential to impact on a number of other extension processes, including Landcare and the developing DPI Information centres.

#### **ACKNOWLEDGMENTS**

Research funded by the National Landcare Program and undertaken by author while on secondment to Department of Primary Industries, Queensland.

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## SOIL CONSERVATION DISTRICT PLANS A MOTIVATING FORCE IN PASTORAL SOUTH AUSTRALIA.

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#### **ABSTRACT**

Soil Conservation legislation in SA recognises that good local land managers are experts in their field. This legislation provides for Soil Conservation Districts and Boards to be established. Each Board is required to write a Soil Conservation Plan for its District. The District Plan must identify the resources of the district, land use, land degradation issues and best management practices. To assist Boards with the development of their District Soil Conservation Plan a series of workshops have been designed which structure and focus attention on sections of the plan. In this way local information and expertise has been collected and recorded for inclusion in the District Plan.

#### INTRODUCTION

Soil Conservation Boards consisting of seven local people nominated by their community become responsible for soil conservation awareness, education and promotion of the principle that land be used within its capability. To assist with identifying issues and priorities, each Board is required to produce a District Plan. The plan describes land resources, identifies degradation problems and sets out guidelines for sustainable land management. The District Plan also includes a three year program of activities which requires each Board to identify its aims, objectives and activities. This has encouraged Boards to form Landcare groups, hold field days, and distribute questionnaires to canvass local opinion and identify district issues. The District Plan is a motivating force for soil conservation action.

#### **PROCESS**

The development of a District Plan is a process by which Boards gain knowledge and a range of planning, communication and education skills. My role as facilitator has been to draw from the Board members their knowledge of the country they know and manage. To succeed, I have developed a range of structured workshops which focus attention on one section of the Plan at a time.

## Description of the district.

The first section of the District Plan needs to describe the resources of the District. This may have most easily been done by researching and writing the section myself. However to maximise the ownership of the District Plan by the Board who is ultimately accountable for it, I have involved them in identifying issues and describing resources under headings.

Topics including land use, history of land use, water resources, and infrastructure issues and descriptors are "brainstormed" and listed on butchers paper. A board member is then nominated to further research each topic and write a draft or, to co-opt someone else in the community to write the section for the Plan.

A climate summary for each District was prepared by the Bureau of Meteorology based on the topics chosen by the Board from a "shopping list" provided by the Bureau's consultant.

In Districts for which a land systems map did not exist, the Boards have mapped and described the Land Systems of their District using satellite imagery, geology maps and their own knowledge of the country. For these Boards the experience was rewarding and informative.

The workshop approach has enabled the Board members to share their knowledge of their District and helped them to focus attention on topics in a structured way. The process used has extended the involvement in the development of the plan into the community.

## Land degradation and land management

The next step was to identify the inherent limiting factors, types of land degradation, land capability and best management practices for each land system. Board members, working in small groups, compiled necessary information using the above headings. Visits were made to those areas with which the Board members were unfamiliar.

## Community consultation

The Board is required to consult with the community as widely as possible in the development of the District Plan. Many Boards have used questionnaires to identify issues and priorities. Responses to the questions have provided direct input into the land degradation and land management sections of the Plan. The questionnaire has also identified projects that the Board might undertake.

Field days have been to illustrate aspects of the District Plan during its development. Plant identification field trips, rabbit and goat control field days and meetings to allow locals to edit their Land systems maps have been held with very good attendance.

## Three year program of activities

A three year program of activities is also required in the District Plan. The development of a vision statement, a list of prioritised objectives and activities are the steps in a goal setting workshop. The use of the Nominal Group Technique involves all board members in this process. Boards that have not previously defined their aims have found this an inspiring workshop which has given them direction and focus.

#### **INSPIRATION**

Though the task is daunting, District Plans have inspired Boards to:-

- Think regionally.
- Learn about the resources of the region. The description of the district section of the plan involves all members in knowledge sharing and research.
- Understand the process of degradation. Board members must first identify and understand the processes of erosion and degradation before they can assess it.
- Identify best management practices for each land type. Several board members have changed their stock management since working on the plan.
- Identify gaps in knowledge and seek assistance to solve problems. Identifying issues and priorities on a regional basis often highlights more questions than answers. Land Care funding has been used for trials and field days and/or to employ co-ordinators to assist with programs.

#### SKILLS DEVELOPMENT

Throughout this process, Board members acquire a range of skills. These include:-

**Networking.** Boards identify themselves as the networking link between the community and Government on land management issues.

**Planning and Goal setting.** Members of boards acquire skills in identifying goals, setting priorities and planning activities.

**Report writing.** Though most members would not see themselves as report writers, they acquire knowledge about how to structure a report and address a target audience.

**Team work and leadership.** The development of a vision, objectives and issues requires team work. Leadership skills are practiced as the Board is required to market its plan and foster the land care ethic in their region.

**Negotiation.** The District Plan provides a community accepted standard for land management in the District. In the few instances where land managers have had to be approached about land degradation, the Board has been at the forefront of negotiation.

**Extension.** As issues are identified, Boards plan and run field days and information days. The Board is assisted by PISA extension staff.

## **CONCLUSION**

A series of workshops have been developed to assist Soil Conservation Boards develop District Soil Conservation Plans. These workshops have facilitated the collection of local information and knowledge by involving Board members. As a result, Board members experience a range of techniques and skills which are useful for managing future activities and come to own a product for which they are accountable.

## PRACTICAL RANGELANDS INFORMATION TRANSFER IN CENTRAL AUSTRALIA

Centralian Land Management Association

PO Box 2534, Alice Springs NT 0871

#### INTRODUCTION

The Centralian Land Management Association was formed in 1988 with the primary objective of promoting management practices that will ensure sustainable and productive use of central Australian grasslands. To assist in achieving this objective clear, concise and effective interchange of ideas is essential. We consider this is based on three components: Research, Extension and Application.

## POINT ONE:

The first source of information for useful extension is Research. Too much of research findings are never presented in practical terms and too much data are gathered and never analysed, or are lost. These result in extension of information from research not getting through to those who need it most.

The first problem that must be addressed to upgrade the Information Transfer Process is the role and objectives of research. Pure research for research sake is the role of Universities and private foundations. Industry research must get back on the track of usefulness and actions. Results must be understandable. Interpretation must be based on a positive approach to support the management decision-making process. The taxpayer will then gain maximum return for the invested dollar and community aspirations will be fulfilled. The Landcare movement, through land manager input and participation, is trying to address these problems.

The role of government is to set in place services to all land managers. As the elected representative of the people it should allocate the public purse (taxes) to fulfilling community expectation and presenting strategies through its appointed agencies. For the purposes of this paper, a land manager is a person or group who manages land, be it for whatever intention.

## POINT TWO:

Research people generally do not make good extension officers, neither have they experience with, or expertise in, socio-economics. The middle tier of agency officers who can, by training, interpret research and convert findings to practical techniques, is the answer. This tier needs fostering.

Research is not being utilised mainly because of the inability of this to be interpreted in a positive and usable way for management. The extension officer, be they of a pastoral, cultural or any other land manager service, must be able to understand the constraints facing the land manager. There needs to be a massive attitude change by researchers to include the experience of land managers and their genuine concern for sustainability, both economic and ecological, of the resource.

Public perception is through: \* Group meetings \* A Newsletter \* Workshops

All data and reports that have been stored over the years must be assessed and this, the agency extension field, is the logical place to do it. Access can be to both researchers and end users. It follows that this interdepartmental group should communicate clearly within each land use field so that cooperation, not confrontation, results.

The role of the land manager is to use, within his Property Management Plan, information that is available and apply it on the practical level. His experience will identify any short fall in the use of findings and identify gaps, which through communication with extension officers, should then define the lines that research should be taking.

#### **POINT THREE:**

CLMA represents one landuser group - Pastoralists. From our perspective, all of the above applies. Our method of spreading positive results to achieve both economic viability and to satisfy public perception is through:

- Group meetings
- \* a Newsletter
- Workshops

- Personal contact
- Field days
- Agency liaison

Subjects addressed in the last 3 years include:

- \* Construction and design of ponding banks
- \* Purchase of a laser truck to support water harvesting
- \* Re-assessment of Cunningham's 1965 data
- \* Encouragement of the formal Property Management Plan process
- Practical rabbit control
- Weed control a new field being developed
- \* Responses of different species in re-vegetation trials
- \* Test the potential production of different land types
- \* Fire ecology the role of fire in management
- \* Assessment of land reclamation equipment
- \* Climate effects especially type of rainfall event
- Spelling a new trial to assess response
- \* Water harvesting the only real production-improver
- \* Road/fence/firebreak erosion the cause of 80% of gullies
- \* Resource monitoring what is/has happened? why!
- \* Representative community identification base data

In the broad context of land management and extension in these parts of Australia defined as Grasslands, that is areas where cropping is not practical, some twelve major regions can be identified. Regionalisation is an ideal to aim for but the reality of political boundaries has to be considered. Rethinking to adjust to the regional approach will, through mutual cooperation, lead to the most rational use of financial resources (tax). Landcare is based on regional like interest and is expanding across State boundaries and the various types of land use. This development, grass roots driven, will be the direction for the future. As the formal user-driven Property Management Plan process develops and the State/Territory Landcare Councils draw together the interests of the various land users, a far better information transfer process will evolve.

#### MULTIMEDIA - ANOTHER TOOL FOR RANGELAND INFORMATION TRANSFER

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#### **ABSTRACT**

Multi media applications have generally concentrated on sophisticated productions using CD-ROM technology and the whole panopoly of extras that are available - video, sound, still pictures, graphs and text. However, for many applications involving brief informational, educational or instructional material it is possible to adapt the technology to operate with sufficient colour pictures and text in an easy to use structured environment that can be fitted onto a standard three and a half inch diskette. This does not require any software [except Windows]. We believe this offers a new and exciting opportunity for information transfer of particular application to the remote rangelands areas in Australia. While the application demonstrated illustrates water manipulation practices for rangeland productivity, it has wider application including other aspects of the rangelands including pastoralism, wildlife, tourism, mining, community development and training.

## INTRODUCTION

There is an old adage "that a picture is worth a thousand words". This is even more important when operating in informational, educational, teaching or training situations where text can be supplemented by pictures.

The use of interactive learning has been explored and developed to a high degree in both the business and information technology sectors through the development of sophisticated video and interactive disk-based computer learning programs, and in most recent times by interactive CD-ROM systems. Often the purchase cost of these is quite high, but acceptable to organisations for they provide experiential learning at a much lower cost per individual. However they are expensive to produce and consequently quite costly for each topic covered. Often they cannot be produced for many subject areas, especially for the low population density in the rangelands of Australia, because the cost is high and demand low, thus precluding recovery of expenses.

#### **PROCEDURES**

Multimedia using a personal computer is an alternative option. So far, this option has been restricted to use of upper level hardware and peripheral equipment, and an attached CD-ROM unit. As newer or replacement equipment moves into this category [e.g. >80% new PC's sold in the USA have CD-ROM included], more options are available, as can be seen by the plethora of titles now available for this market. However, satisfactory information and training modules can be developed to operate on an industry standard 1.44Mb diskette.

The disk contains both the specialised program, written in Visual Basic, as well as the data, which can be text, graphics and photos.

Photos are input either as digitised images from existing colour slides or standard colour negative film utilising commercial services which produce digitised images on a photo CD such as are available from Kodak. This can be done retrospectively from existing slides or film, or by having film processed in this format. Alternatively, images can be scanned from a colour [or black and white] print via a colour scanner, and read into the computer directly. Text and graphics are input via the keyboard or from floppy disks.

A front end menu incorporating both photos and text boxes provides the direct access to the information package using standard "drag and drop" techniques using a mouse. This enables the user to move through the information package using a series of levels of increasing complexity of information in a vertical facade or to remain on a horizontal facade to obtain broad scale information, with the option of moving vertically for increasing complexity of data as required.

About 2Mb of compressed data can be encapsulated on a standard 3.5 inch floppy. This allows 15-20 colour photos, a range of graphical material and up to 100 pages of text. Naturally, there is a trade off between visual and textual material, with the visual material being more demanding of diskette space. In effect you can produce comprehensive training or instructional material simply, at modest cost without the expense of complex video instructional material. The package can be put together using the photos and text the client wishes to be included. Like any published material, presentation skills in arranging the contents can be important in giving the best results.

This can be assembled on a floppy disk as a "one off" instructional or information package or used as part of individual information, education, or even promotion messages, or made up as "interactive fact sheets" which can be copied for distribution. Costs of this system are a modest few hundred dollars, and modifications or updates are easily done. By contrast, video productions can cost thousands of dollars and rarely can they be easily updated. Alternatively, where access to a CD-ROM unit attached to a modern PC is available, the same program allows development of more complex systems introducing all the available options and with extensive use of video film clips and still pictures, but obviously at greater cost.

#### **DISCUSSION**

The demonstration being shown at the rangeland conference covers the techniques of both waterponding and ponding banks for rangeland productivity enhancements in central Australia. Photos were not professionally taken and colour prints as well as colour negatives and colour slides, from standard quality 35mm colour film, have been used.

Over much of the rangeland areas of Australia, there are many widely scattered properties and many have access to a computer - others have access via town libraries, schools, Landcare groups and similar bodies. Ideally, the better the processor the faster the system operates, but any machine from a 386SX up and operating Windows will run the floppy disc. A CD-ROM is NOT needed. More sophisticated systems using full CD-ROM technology are already operating.

Getting people to read information is not always successful, but interactive processes are often more successful in transferring information. This is particularly relevant, where pictures and diagrams, often leading the user through the process, can be more helpful. The system may also have application in many Aboriginal communities, where language difficulties may impede textual communication.

## A DSS FOR COMPARING THE FEASIBILITY OF DROUGHT MANAGEMENT TACTICS IN AUSTRALIA

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#### **ABSTRACT**

The management tactics used by Australian rangeland pastoralists to cope with drought, and their associated costs, were identified in a workshop in March 1993. A means of assessing and comparing these tactics has been incorporated into **Climate**, a new module in the **RANGEPACK** series of PC-based software programs. In addition to drought management assessment, **Climate** allows managers to examine climatic data from regions around Australia and to calculate the probability of a variety of climatic events, providing an invaluable tool in the management of climatic variability.

#### INTRODUCTION

Managing for drought and climatic variability is a major issue in the Australian rangelands. Following an extensive survey of rangeland managers, a workshop was conducted to identify all the strategic and tactical options available that attempt to cope with climatic variability (Stafford Smith 1994). As part of the **RANGEPACK** project, a new software program, **Climate**, is being developed to assist managers in handling climatic variability and to compare various drought management tactics. **Climate** joins two other products currently available in the **RANGEPACK** stable: **Herd-Econ**, linking the biology and economics of a property to assess strategic management options, and **Paddock**, predicting the long term patterns and efficiency of paddock use.

## **CLIMATE DATABASE**

The engine behind **Climate** is a database accessing climate station data for regions across Australia. Basic functions are provided within **Climate** to examine the raw rainfall and temperature data, as well as calculating maximum and minimum values, monthly and annual totals, and monthly means.

We can not predict the future, but we can examine previous climatic data and calculate the probability that events will occur. A simple menu system in **Climate** guides managers through two simple but useful rainfall probabilities. There is access to more complex probability calculations at a lower level of the program. The two questions addressed by the menu system focus on the probability and timing of a significant rainfall event which is defined by the manager.

- \* The first calculation determines the probability that a significant rainfall event will occur in each month of the year. The output from this calculation is displayed in Figure 1, which also shows the graphical, menu based nature of **Climate**.
- \* The second calculation examines the cumulative probability that an event will occur from a given time. This provides useful information on which to base decisions like: how much longer might I need to feed my animals?, or: at what point should I declare that rains will probably not come for this year (and plan my actions accordingly)?.

Associated with these probabilities is the idea of betting odds; determining the level of risk that a pastoralist accepts. This is the level of probability/risk that a pastoralist is willing to gamble that the event will occur. Given these betting odds, **Climate** can determine the time that these odds are reached and perhaps when decisions must be made.

## DROUGHT MANAGEMENT TACTICS

As well as identifying the drought management options, the workshop also tried to determine the costs associated with each tactic (see Stafford Smith and Hope poster). Using the results of this workshop in conjunction with a number of Government agencies across Australia, we have incorporated a means of assessing the viability of the various drought management options into **Climate**. **Climate** attempts to examine all the costs associated with each management option,

including an estimate of the likely build-up cost after the dry period and cost of the expected environmental impact. Through an interactive process, the manager is asked to estimate the various values which affect each management option, as well as the number of stock which will be affected by each tactic. Using past climatic data for the region, **Climate** generates a best case, most likely case and worst case scenario for the length of a dry spell and produces a total relative cost for each management option in each of these scenarios. This gives the manager tangible values on which to base management decisions.

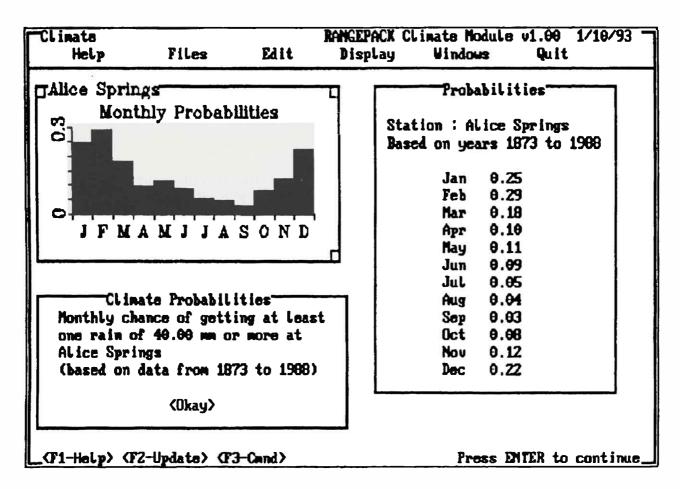


Figure 1. **Climate** screen display of the probability of getting at least 40.0 mm of rainfall in the Alice Springs region in each month.

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## HERD MANAGEMENT PLANNING FOR SUSTAINED PRODUCTIVITY AND PROFITABILITY: TARGETING SELLING AGE

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#### **ABSTRACT**

Gross margins are calculated for a range of production combinations and turnoff ages for a herd in the Katherine Region. The results are then used to determine the break-even prices for steers of various ages compared with steer sales at  $2\frac{1}{2}$  year old (y.o.) this shows the price premium required or penalty incurred if they are sold at a younger or older age.

#### INTRODUCTION

Determining the best age and weight to sell steers are important issues when developing a herd management plan. Producers in the Katherine Region have traditionally sold their steers at  $3\frac{1}{2}$  y.o. or older. During the past three years the markets for live steers to South East Asia have offered higher unit prices (\$A/kg live weight) for younger steers which meet specifications. Other competing premium markets are the weaner store market in the eastern states and an expanding demand for weaners for finishing in the Katherine/Daly area.

Targeting the most viable option involves determining the price differentials between markets for steers at different weights and ages and the costs of producing steers for these markets. Growth rates, age at turnoff, stocking rates for different classes of cattle and changes in herd structure and value, must be taken into consideration.

#### **METHODS**

The static form of the herd model SUPERBOSS (Michell, 1992) was used for the analysis. Gross margins per adult equivalent (AE) were calculated incorporating changes in stocking rate, herd size, structure and value, for 52 possible production combinations for a 4000 AE herd in the Katherine Region. The production possibilities used were the result of two supplementation options and four turnoff ages (see Table 1). Combinations of 4 variations in steer weaning rate, 5 weights at weaning, 2 sets of post weaning weight gains and 2 variations in mortality rates for steers and the breeding herd, dependent upon the level of supplementation, were used.

Within each production system the price for steer turnoff at 6 months,  $1\frac{1}{2}$  y.o. and  $3\frac{1}{2}$  y.o. which would produce the same gross margin as sale of  $2\frac{1}{2}$  y.o. steers was calculated. From these results the premiums required above the prices for  $2\frac{1}{2}$  year old steers for it to be more profitable to sell at a younger or older age can be deduced.

## **RESULTS AND DISCUSSION**

Results of the analysis are shown in Table 1. Prices used reflect 1992 average prices. Whilst the relativities remain the same the differentials calculated in this study should also remain.

Weaner turnoff becomes more profitable as weaning rates and weaner weights increase. For weaner turnoff to be the most profitable option a premium of more than 20c/kg (the usual premium offered) above the price for 2½ y.o. steers is necessary in most of the scenarios examined. The premium required is less than 20c only where the highest weaning weights (200 kg) are achieved, or 75% weaning with weaning weights of 170 kg or more. In the Katherine area this is only likely to occur in more intensively managed herds on improved pastures and supplemented throughout the year.

Steers from supplemented herds at weaning rates of 70% or more can be sold at  $1\frac{1}{2}$  years more profitably than holding them to  $2\frac{1}{2}$  y.o. or older. Steers from unsupplemented herds require a price premium of 2 to 9 c/kg at 18 months to be sold as profitably as  $2\frac{1}{2}$  y.o. steers.

Table 1. Break-even prices (\$A/kg liveweight) required for steers at various ages to produce gross margins equal to those at 2½ yrs in five production systems at various weaning rates

Turnoff	Live Weight		W	eaning R	ate	
age	(kg)	50%	60%	60%	70%	75%
Production Sy	Production System 1 (Unsupplemented)					
6 months	130	1.56	1.47			
1½ years	220	1.09	1.06			
2½ years	290	1.00	1.00			
3½ years	320	1.11	1.14			
Production Sy	stem 2 (Unsupplemented)					
6 months	150	1.41	1.30			
1½ years	240	1.05	1.02			,
2½ years	310	1.00	1.00			
3½ years	340	1.11	1.14			
Production Sy	stem 3 (Supplemented)					
6 months	150			1.33	1.23	1.18
1½ years	280			0.97	0.94	0.93
2½ years	380*			0.95	0.954	0.95ª
3½ years	350			1.04	1.04	1.05
Production Sy	ystem 4 (Supplemented)					
6 months	170			1.31	1.22	1.17
1½ years	300			1.01	0.99	0.97
2½ years	400			1.00	1.00	1.00
3½ years	470			1.08	1.10	1.10
Production Sy	ystem 5 (Supplemented)					
6 months	200			1.17	1.09	1.04
1½ years	330			0.98	0.96	0.94
2½ years	430			1.00	1.00	1.00
3½ years	500			1.08	1.10	1.11

<sup>&</sup>lt;sup>4</sup> An on-property price of \$1.00/kg LW was used for all 2½ y.o. steers except those weighing 380 kg. These were valued at 95c/kg LW as they are outside the age and weight specifications for the live export markets.

Major changes in herd structure and the capital value of the herd occur with changes in turnoff age and management intensity. The opportunity cost of the changes in the value of the herd must be included when comparing herd profitability. Management implications for running more breeders must be taken into account.

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# BEST PRACTICE FOR TECHNOLOGY TRANSFER - AVOIDING LOST OPPORTUNITIES THROUGH IMPROVED INTEGRATION OF R,D, & E

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#### **ABSTRACT**

Pay-offs to R&D are lost when results are not adopted. Past failures have commonly been put down to extension problems, whereas the R&D itself may also have been at fault. However, recent moves to raise adoption through new participatory extension approaches, while worthwhile, may also create new problems for R&D portfolio managers if not planned effectively. Best practice for technology transfer in a rangeland R,D&E context has still to be defined.

#### INTRODUCTION

The sentiments lying behind the theme of the present conference - clean practice, clean country, clear profit - will reflect an ideal that we are sure is shared by many people with an involvement in rangeland pastoralism, both at the production level and those that indirectly support it, including research and extension. However, the fact that a major national conference should be based on this theme, is also reflective of a widespread view that present practices are in reality, falling short of this ideal. That is, present practice is by no means 'clean' practice or 'best' practice, and it is certainly neither ecologically or economically sustainable. The proof for this assertion will be the large number of contributions to the conference that address the downside of one or more aspects of present practice, or advocate change in the way things are done in the future. Much of this material will be based on the work of research and/or extension professionals or will be calls for such work.

This is consistent with a view that many of the more pressing problems facing rangeland managers can be successfully addressed by research, development and extension activities (R,D&E). This is not unreasonable, as there is considerable evidence to show that the potential return on such R,D&E, to both individual managers and the community, can be very high. However, we have intentionally highlighted the conditional nature of the return to research portfolios managed by the R&D agencies. Best practice in R&D management, like that of its rangeland management counterpart, also falls short of its promise, which at a time of shrinking resources (i.e. funds and skilled personnel) and increasing demands for accountability is problematic. The reality is that the realised return on rangelands R,D&E is, in many instances quite poor, and this is occurring for reasons that we believe are both understandable and, with some application of 'best' practice, avoidable.

## **CONVERTING POTENTIAL TO REALITY**

The tragedy remains that so much of the past R,D&E investment in rangeland management problems has, ultimately, been wasted through limited or nil adoption of the results. Much of the output of R&D projects and programs did not progress beyond the journals to become real outcomes, in the sense of being adopted as so-called 'best' practice by significant numbers of practical managers. As such, R,D&E managers have yielded a sub-optimal return on their portfolios. This result has commonly been put down to extension or communication failures, whereas it may equally be symptomatic of research failures, for example, through poor problem definition or mismatches with stakeholders' real needs. However, it is more likely that both research and extension are at fault and that the problems are inherent to the institution and system of R,D&E as practised for rangeland activities.

How might these problems be overcome in the future? The answer would seem to be provided in the first instance by the R,D&E managers and their operatives seriously asking questions about the institutional system including who their stakeholders actually are, what the reality of their construct of the world is, and how they might really use the outputs of the research being conducted or proposed. The process would also seek to identify the stakeholders' preferences for an alternative construction of the R,D&E portfolios. This is a different exercise to that of asking certain 'clients' if they believe that the proposed outputs that are being planned by the agencies are likely to be 'useful'. It is also different to striking up a working relationship with extension or marketing 'experts' after the

die for the R&D has actually been cast. Both of these approaches are becoming more common. However, our experience in dealing with both R&D management and needs assessments for multiple stakeholders has led us to believe that they are not likely to be particularly fruitful - given the complex issues that are being raised about sustainable rangeland resource management.

Alternative models are emerging under the guise of participatory research processes, that seem to advocate near-total empowerment of the different stakeholders - although the reality seems to more closely approach empowerment of only some of the stakeholders. While this approach has some value in targeting R,D&E towards useful and usable ends, it also carries the risk of sub-optimal portfolio selection through concurrent disempowerment of certain stakeholders and failure to deal with a changing landscape of stakeholders over the duration of the R,D&E program. Not least important among these is the R&D-providing agencies themselves (not to forget their majority shareholders, the public at large). There can be no guarantee that key stakeholders will necessarily identify and pursue interests that are fully consistent with those of the population of stakeholders. Nor can we assume that these key stakeholders will be stable. In fact, if the R,D&E processes are successful, it is highly likely that the interests and involvement of stakeholders will change. For instance, when a key stakeholder is part-funding the R&D (or some other part of the agencies' portfolios) the likelihood of real philantrophy diminishes as either success against original objectives or new objectives become visible and proprietary claims set in.

Therefore, while the user-empowerment models claim superiority on grounds of their holistic design giving rise to an emergent property of positive-sum outcomes to all stakeholders, the reality seems to approach a zero sum outcome for some participants, including the R&D providers. We see a need for R,D&E managers to clearly understand the central elements of their agencies' mission, who the stakeholders really are, and what their legitimate needs and claims are. These should then be intelligently addressed through an appropriate balance of targeted communication and feedback through the main phases of the project cycle. For these ends, there are a number of useful models and approaches that can be followed. The fundamental issue is to intelligently and fairly address the efficiency, efficacy, and equity of their application from the perspective of all of the stakeholders to the R,D&E.

## **CONCLUSION**

The challenge for R&D managers is to recognise the balance required to achieve genuinely 'client-valuable' outcomes as opposed to the necessity of pursuing 'client-driven' outcomes. Or worse - 'cliche-driven' outcomes of little tangible worth in the sense of real world change towards widescale improvement in rangeland resource management.

We have suggested the need for major changes in the way rangeland R,D&E is managed. Yet before these changes can be acted upon, some basic issues are yet to be addressed. For instance, the question of 'what is best practice(s)?' will need to be answered. In many industries the standards for best practice do not as yet exist within that sector and standards are taken from elsewhere (e.g. hospitals are using 4 star hotels). Which industries should rangeland management be using? Where have adoptable best practices of R,D&E management been demonstrated? Most of the success stories about best management practices have stepped away from focusing on executing an existing practice more efficiently to addressing the issue of effectiveness. Yet much of the current rangeland R,D&E management remains oriented to increasing efficiency. Preliminary answers to these questions are presented in the accompanying poster.

#### PASTORAL PLANS - AN AID TO MANAGEMENT PLANS

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#### **ABSTRACT**

A pastoral plan is a plan of a station drawn to a suitable scale, and showing topographical features, infrastructure, land systems and, where known, carrying capacities.

Pastoral plans are an aid to producing an effective management plan because they show a producer where to site water points and fences to use his pasture effectively and to calculate paddock stocking rates.

In the future they could be used in conjunction with NOAA satellite imagery to estimate paddock biomass relative to the previous year, with stock numbers per paddock adjusted accordingly.

## **INTRODUCTION**

The Department of Lands Administration (DOLA - previously known as the Lands Department) used to produce station plans. When pastoral inspectors were absorbed into the West Australian Department of Agriculture (WADA), WADA took over this role. Today base data from station plans, resource surveys, and topographical maps are captured by GIS and plotted to produce a pastoral plan. Resource surveys are carried out at approximately five-yearly intervals and range condition recordings are made in accordance with the method developed by Payne (1979). Any changes in the infrastructure are recorded at the same time.

#### **METHOD**

DOLA supplies a basic station plan showing the original infrastructure, topographical features and cadastral information. A team from WADA then visits the station and updates the position of tracks, fences and water points using a GPS. Using these data, a traverse of the station is then made covering the major land systems to assess range condition. Land system boundaries are obtained from air photo interpretation or from land systems maps developed by Payne (1974).

All of this information is then captured by GIS and plotted to produce a pastoral plan at a suitable scale (usually 1:100,000) and sent out to the station for correction. After correction, the pastoral plan is then supplied to the station. Carrying capacities for most land systems have been calculated by Payne (1979) using estimates of pasture types in varying condition.

## **DISCUSSION**

Using the appropriate carrying capacity and a five kilometre grazing radius (or other appropriate distance) it is possible to calculate a carrying capacity for each paddock.

These stocking rates should be used as a first approximation and then adjusted according to season and trend in range condition.

Where practical, fences should follow land system boundaries.

The pastoral plan indicates which areas of the lease have the highest carrying capacity and these, together with condition ratings, show which country is worth developing first. Where carrying capacities are low and water point costs are high, it may be uneconomic to install water points. Sacrifice areas around waters may occur when more than three hundred head of cattle water from one point.

In the future NOAA imagery may be used to indicate biomass in each paddock and this information used by the pastoralist to adjust his stocking rates, by comparing the biomass from the previous year.

Pastoral plans or maps are usually of great interest to the pastoralist and provide an opening to discuss many management-related topics such as pasture monitoring, paddock spelling, the value of perennial plants and rangeland condition.

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# GROUP INITIATING PROCESSES TO INVOLVE STAKE-HOLDERS IN SPECIFIC PROBLEM AREAS

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## **ABSTRACT**

Three approaches useful in forming action learning groups are outlined, to assist other rangeland research and extension staff considering group activities to enhance adoption. The groups have all been successful to date, as they have focused on specific problems which are important to them. This appears to be more important than the group formation process chosen.

## **INTRODUCTION**

Low rates of adoption of research findings have been a consistent problem in Australia's rangelands (Russell and Ison 1988, Fitzhardinge 1993). The Queensland Department of Primary Industries has adopted a group extension approach to address this issue, utilizing action learning techniques and encouraging participation of all stake-holders (Anon, 1992). Three different approaches to group formation have been used in western Queensland. This paper will outline those methods and draw comparisons and generalizations on the benefits and downfalls of these group initiating techniques. The progress gained by using these techniques will also be outlined.

## **CONVERGENT INTERVIEWING (ROBERTS)**

The technique of convergent interviewing (Dick 1987a) was used to identify an issue important to woolgrowers. A group was formed to examine the resultant issue the graziers selected. The group initiation was grazier driven, with each grazier originally interviewed nominating one or two possible others. The group has operated using the Kolb learning cycle (Kolb 1984) and has focused on the issue as well as the processes used in the group.

The issue identified by the convergent interviewing, and the focus for the group is "the role that I, as a woolgrower, can play in preparing and selling my wool". The group members have drawn on their own experiences in the group to contribute to the formation of a second action learning group.

#### ADVERTISING FOR EXPRESSIONS OF INTEREST (JONES)

Interested graziers with woody weed problems responded to an advertisement in a local newsletter and nominated 6 - 8 other grazier participants on neighbouring properties with similar vegetation and problems. Groups also included 2 Queensland Department of Primary Industries staff. Using group action learning processes, the groups determined their own mission statement, defined the main woody weed problems and determined action plans to address these problems.

To date, activities have included property visits to examine and discuss other members' management, information gathering including other government agencies, chemical and mechanical trials, and several groups have applied for landcare funds to take group activities further.

## **SEMI-STRUCTURED INTERVIEWING (PHELPS)**

Thirty graziers were initially approached to gauge interest in joining a group to research the control of feathertop (*Aristida latifolia*). A semi-structured interview technique (Minichello *et al.* 1990) and predefined selection criteria were used to select the final 8 grazier group members.

The group has defined the problem in their own terms. Potential control measures have been recommended and are currently being trialled (burning, grazing strategies and pasture-topping).

Practical aspects and potential benefits of the research have been better explored through the group processes.

#### DISCUSSION

A number of generalizations can be drawn from each of the three processes. The first is that the groups, once established, have been active and successful because they have a specific problem to focus on. The second, is that each group member participates because they are stake-holders in that specific problem. If these conditions are not met, we believe the groups would not be successful - irrespective of the initiating process used.

There also appears to be the need to establish the boundaries, early on, within which the group needs to work.

Some of these boundaries may be pre-defined, unchangeable, and beyond the group's control. These can include organizational limitations and funding requirements. Other unchanging boundaries, such as the specific direction and focus of the group and the time available to participants should be set by the group. All fixed boundaries should be understood in the first group session. This provides a better foundation for the planning of group activities, smoother group functioning and a greater chance of success.

Some boundaries may be more fluid, such as dates of meetings, time spent at each meeting, and the people present at the meeting (it seems unavoidable that not every participant will always be available, and on occasions it is useful to invite other people who have expert knowledge to share). Even with set boundaries, grey areas can appear. One example is where the facilitator is also a member of the group, with his or her own expert knowledge and opinions. This can be a difficult situation for that person, and an area of potential conflict. Distinct procedures which show other group members when the person is facilitating or contributing in another way, can be useful here. The common themes, then, are the specific focus, participation of stake-holders in the problem and the need to set boundaries.

Convergent interviewing has proved successful to date in establishing groups where there is no predefined problem. The other techniques appear to be well suited to forming groups around an existing, known, problem such as woody weed invasion or feathertop. The semi-structured interview assisted in selecting a single, well balanced, group to address a research topic. Advertising was useful to form a number of groups, each selecting a particular woody weed as their focus.

#### **ACKNOWLEDGEMENTS**

We would like to thank the other members of the groups for their participation, and the AWRAPO for the funding of the three projects which this paper has drawn on.

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## **QPASTURES - FORAGE PLANTS DATABASE**

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#### **ABSTRACT**

Most forage plants tested in rangelands will probably not be commercialised for some reason. A formal journal publication is also unlikely from most evaluation trials. Without that, future generations will be denied the results unless a computerised database exists to summarise the data. To have confidence in the results, staff must also maintain the work for many years - at considerable cost. The chances to repeat or embellish earlier work will be few in the foreseeable future.

QPASTURES is a database which records structured summaries for any plant evaluation work conducted in Queensland. It is online on the Queensland DPI computer network and available to anyone with access to that network or by arrangement with QDPI staff.

## **INTRODUCTION**

"Will oldman saltbush grow on my place?"

"What do you know about Supergrass?"

"Is there a suitable native species with which my paddock can be resown?"

These are three of the most common questions asked of agronomists and rangeland advisers. Depending on the adviser's experience and knowledge, the reply may be simple or very vague. Vagueness is common because many trials with forage plants are not documented in such a way that others can benefit from the results. Thousands of grasses, legumes, shrubs and forbs have been tested by many people, often with very different objectives. Such trials, large and small, continue but seed importation to Australia of potential crop and pasture plants is becoming increasingly difficult, more expensive and also much slower. Some overseas countries are now strictly controlling export of any native plant material.

## THE QPASTURES CONCEPT

We need to capture the information from these trials so that everyone can benefit. Queensland DPI has taken the first steps to do this (QPASTURES 1991). Since 1987 we have been slowly building a computer database of most pasture accessions tested in Queensland. It is dynamic and includes results - not just lists of plants received (*a la* Australian Plant Introduction Review) or plants grown in glasshouses for morpho-agronomic classification.

QPASTURES includes information about botanical name changes, major publications on a species or genus, tribal affinities of species, alternative code numbers to the often-used CPI numbers and about seed stocks held by QDPI. It provides as much information as possible about the plant's homeland and about the sites where it was tested in Queensland. Detailed climatic and soil data are provided for most Queensland sites. It tells you who tested the plant, so you know who to call for more details. QPASTURES tells you how plants performed relative to common standard plants which would normally be sown or grow naturally at that test site. Information is held about all released cultivars which have been tested in Queensland. Rangelands have a much smaller call on the system than higher rainfall areas but nonetheless the concept is valid and data from Charleville and Longreach are provided already.

Two important feature of QPASTURES are scrupulous spell-checking of botanical names and cross referencing of accession numbers for accuracy. Quite extensive onscreen help is available to guide the novice user. A consistent system of ratings is used for many agronomic characters such as persistence, drought tolerance, ease of establishment etc, - 1 means very low or very poor, 4 is an average rating and 8 is the top rating (the value 9 is reserved for unknown while zero indicates an inappropriate field to be assessing for that accession e.g. nodulation of a grass). Up to 38 characteristics about a tested plant and 44 attributes of sites can be rated or described in this structured way using widely accepted classification systems (McDonald *et al.* 1984).

#### **CURRENT CAPABILITY**

Only standard ASCII text is used and no graphics are currently employed. Output can be to a screen, file or printer. At present only minimal formatting of the output has been attempted. Hence much of the data is coded and the user would need the help of a printed QPASTURES Manual to interpret some of the data.

Searches of a general nature can be done by either (a) supplying the name of a shire or delineating latitudes and longitudes for the region of interest or (b) providing an accession number or species name in a query form. Updating with extra data or missing data can be done later once the primary data about accessions and trial sites have been loaded. The characteristics which may be rated or described in a performance report on an accession need not all be entered on an individual report. The rest can be either left blank and provided later or rated as unknown.

Currently 5,500 accessions are registered plus the list of accessions sown at 250 sites. The projects and accessions entered mostly deal with studies commenced after 1967. Major projects which are currently active are handled by QPASTURES, including the Co-ordinated Pasture Evaluation Project (COPE) funded by the Meat Research Corporation (CS 185 and DAQ 81) and the National Clover and Medic Projects supported by the Australian Wool Research and Promotion Organisation. Once a list of plants is available for a trial, data recording sheets in QPASTURES format can be generated to provide results to the database. Field officers can type results directly into the system although this is fairly slow via normal telecommunication lines from remote centres.

Enquiry access is readily available to the general public from many QDPI centres with landline links to Brisbane. A summary of what files are held for a particular accession gives novice users a quick introduction to the sort of information QPASTURES holds about their plant. More details are then obtained by consulting the appropriate files via the screen menus.

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## LANDCARE IN THE PASTORAL ZONE OF SOUTH AUSTRALIA

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#### **ABSTRACT**

Successful landcare relies on active, ongoing community participation. This involves firstly, understanding the resource. This can be achieved through the district planning program requiring the description of the physical characteristics of the district and determining the management hazards for each land type. Participation in workshops/courses such as plant identification, mammal and reptile trapping and vegetation monitoring and the development of regional plant herbariums all contribute to a broader knowledge base for the local community. The next stage is to identify the major land management issues and to work together with the wider community and government agencies to find solutions.

#### INTRODUCTION

With the introduction of two consolidated and revised acts:- Pastoral Land Management and Conservation Act and the Soil Conservation and Landcare Act in 1989, a firm and supportive legislative base was given for the implementation of the "Decade of Landcare Plan" in the South Australian Pastoral Zone. However, the major thrust of the landcare movement is the community focus and the development of a community "landcare ethic". The majority of landholders/managers are "doing people", interested in landcare through action. The following describes current landcare activities in the pastoral zone. The activities aim to utilise the combined knowledge of the scientists/ technicians with the practical experience of the land managers. The challenge is to ensure that we work together to find solutions to our land management problems, that potential solutions are trialled, practised by the community and passed on to others.

## UNDERSTANDING THE RESOURCE

The Soil Conservation and Landcare Act, 1989, requires the establishment of Soil Conservation Districts with boards appointed to each district. Part of their role is to prepare a district plan and develop community landcare programs resulting in a commitment to better land management. One of the products of the lease assessment process is a land system map defining the "kinds of country" for each district. The different types of country have different land use potential and therefore different management strategies. Todmorden, a cattle station in the far north west of the state, has been described by the local soil board in terms of land systems. The lessee, Douglas Lillecrapp, has used this as a management tool. For example, the Pedirka Land System (L.S.) is dune field country with mulga and woollybutt grass, low in productivity but good as drought reserve country. Todmorden is fenced on the basis of land systems with the Pedirka sand plains (containing only ground water) fenced from the watercourse country. The waters in the Pedirka L.S. are controlled with "in" and "out" trap bayonets with small trap paddocks of about one square kilometre.

The Marree Soil Board is producing a Land Condition Booklet for their district. This booklet will introduce and emphasise the major characteristics of each type of country and the implications for management. The project is a cooperative venture between pastoralists, mining companies, government agencies, rangeland scientists and consultants.

The Marla-Oodnadatta Board has completed a vegetation study of their district. Each station and all local schools have a comprehensive, correctly identified plant collection. The local community was involved in collecting the plants and the data on the seasonal and grazing conditions at the time of collection. The Kingoonya and Marree Boards are attempting a similar project in their respective areas.

Through the Australian Rangeland Society, very successful plant identification workshops have been conducted. Pastoral managers have gained confidence in their plant recognition skills.

Andrew Nicolson from Middleback Station, in the Gawler Ranges, has been identifying community based monitoring systems for the rangelands. The monitoring aims to provide long term records of the status of soil, vegetation and its productivity, and to show the effect of management on the resource. This has generated a great deal of interest, related to the need for better information on rangeland condition and its relationship with business performance.

## **IDENTIFYING THE ISSUES**

In attempting to better understand the resource, some of the major land management issues become apparent. Issues are identified in the district plan and highlighted by the lease assessment process. The Gawler Ranges and the Marree Soil Boards have consulted the community through the use of questionnaires. Feral animal control, especially rabbits and goats, are usually rated as the most immediate issue. Overall grazing management ranks very highly. A number of rabbit control projects are aimed at integrated control options and demonstrating rabbit impact on the resource. Field days have been held in the North East, Northern Flinders, Gawler Ranges and Marla districts. There are grazing exclosures set up in the Marree, Kingoonya, Gawler Ranges, Marla-Oodnadatta and North Flinders districts. These long term projects will provide data on the effects of domestic stock and rabbit grazing on the vegetation in different land types. Landholders are involved in the regular monitoring of these areas.

The Gawler Ranges, Northern Flinders, Marree and North East Soil Boards are part of a coordinated goat control program aimed at determining the most effective control programs and promoting this throughout the community.

## **COOPERATIVE SOLUTIONS**

The findings from the landcare projects will provide much of the information required to implement management solutions. Landholder involvement in monitoring systems, implementation of some of the assessment recommendations and a commitment to a property planning program will also be beneficial. Encouragement is given to all landholders to trial new and innovative management options through field days and regional conferences.

## **CONCLUSION**

There are over 200 landcare groups in South Australia. Whilst only a small percentage of these are located in the pastoral zone, the commitment on behalf of the pastoral land managers is strong, as demonstrated by the above summary of landcare activities. As we are now only just halfway through the decade of landcare, it is most timely to review our progress, to look at where we have come from and to focus on where we are going in the future. Community awareness of landcare in South Australia is high but there is still work to be done to translate this into action. It is important that all landcarers continue to remain committed and that the supportive base formed by the government agencies and scientists be maintained.

# GRAZIER PARTICIPATION IN SETTING RESEARCH AGENDAS: AN OPPORTUNITY TO IMPROVE RESEARCH FOR "ON THE GROUND" ACTION

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#### **ABSTRACT**

This paper discusses research being undertaken in the semi-arid rangelands of New South Wales with grazier families to develop a participative Research and Development (R&D) agenda setting and prioritisation process. This process is seen as an initial step in the development of a broader integrated, participative R&D framework.

#### INTRODUCTION

Participation is being seen more as an ongoing process than as an end-goal. The move away from dependence on the Transfer of Technology (ToT) paradigm with its "adoption" of research outcomes as an end-goal reflects its limitations in dealing with situations which involve more than a simplistic uni-value of maximising production. Social and biological sustainability, heterogeneity, different realities and perspectives, complexity, flexibility, uncertainty and biodiversity are some dimensions of contemporary rangeland contexts which, due to its theoretical underpinnings, ToT cannot accommodate. In this research, "participation as a process" has a different theoretical basis to ToT in terms of what is considered reality (there are multiple realities), useful knowledge (everyone has valid knowledge to contribute), learning (everyone "learns" rather than graziers being "taught" and "adopting"), power (equality, ownership and responsibility), opportunities (rather than problems) and neutrality of technology (it changes experiences). This perspective offers an opportunity to develop different ways of working with people which can lead to more participative, integrated R&D that has the potential for relevant, effective research for "on the ground" action.

#### DESIGN AND CONDUCT OF THE PARTICIPATIVE PROCESS

Grazier families in an area extending from Wilcannia to Wanaaring in western NSW have been invited to participate in the development of a participative R&D agenda-setting and prioritisation process. In the first phase, 36 grazier families were invited, through Semi-Structured Interviews, to reflect on their experiences of research, technology and innovation in their rangeland context, in past and current wool production systems.

The data from this phase were organised into themes which highlighted diversity in graziers' management systems, rather than seeking to generalise. Attention was paid to using graziers' words as much as possible. The data were returned to graziers in a multi-media format (booklet and audiotape) and they were invited to listen to the audio-tape and/or read the booklet. The purpose of this was to seek to establish a context for this research process (that is, how the use of technologies have developed to current systems in this rangelands area and where opportunities for improvement lie that could be supported by research). The booklet offers formal recognition of "local knowledge" perspectives on management systems and issues. Graziers listening to and/or reading other perspectives offer an opportunity for "rethinking" experiences in the light of other graziers' ideas. Reflection on past experiences leading to current experiences seeks to create a "springboard" for exploring future R&D opportunities in the agenda-setting and prioritisation phase of the process.

Following the semi-structured interview phase of the process, graziers were invited to evaluate the process to date. This involved interviews in which graziers critically reflected on what they had read or heard. This included additions and corrections to the material, as well as focusing on the process itself. Everyone involved with the research had to some extent read the booklet or listened to the tape - be it some, or all, of it as soon as it arrived on the mail plane, in bed before turning in for the night, playing the tape in the car as they drove to town or to fix a watering point. In all evaluation interviews there was evidence of graziers having thought through aspects of their own management, how they went about a similar job or decision, questions that were raised, new ideas that were "triggered" through what they heard or read of what other graziers did. Further, many graziers were looking to

specific research opportunities that would be useful to them. At this stage, more graziers joined the process after having heard from their neighbours or seen the booklet.

The interview phase has been followed by continuing collaboration with graziers in the design and conduct of an agenda-setting and prioritisation phase, using a modified interactive "discussion" methodology (Delphi Technique) which does not require people to physically attend group meetings in order to discuss and share ideas. In this phase, graziers have been invited to "look ahead" and nominate opportunities for future R&D which would support their production systems and address issues of concern to them. Graziers participated in the design of the "discussion" exercise and it was conducted using facsimile (fax), telephone and mail as channels for communication. The compilation of the first round "discussion" will be sent by fax or mail to all participants for their consideration.

The following table contains a few areas of research that graziers have nominated as potentially useful and important to support. As much as possible, graziers own words are used and all ideas are valued - there is no consensus seeking. The booklet offers a background to these agenda items.

Table 1. Some useful research that is supported by graziers: outcomes of Round One Delphi "Discussion" exercise.

Topic	Particular Area or Angle for Research
Sheep Lice Control	* Develop sterile lice and control backliner resistance
Rabbit Control	* Continuing research into a substitute virus as rabbits become resistant to existing strains. Need to have another virus ready as one fails to avoid rapid breed-up of rabbits between failure and start-up
Ethanol	* Continue research to develop long-term alternative fuel source from crop waste
Woolpacks	* Develop alternatives packs of larger size and material
Clip Care	* AWC to develop standard rules for clip care, not brokers.  The grower needs to know the requirements based on what the buyer wants
Objective Testing	* Develop an objective micron tester for use in the woolshed
Lambing Percentages	* Develop a pregnancy testing system suitable for use in this area
Selling Options	* What are the options for selling wool now that the floor price is gone? Pros and cons

#### A GRAZIER'S EXPERIENCE WITH LANDCARE

Mark Withers 1 and Stephen Kelly 2

¹ 'Manilla' Station, Wentworth NSW ² Landcare Co-ordinator, Dept. of CaLM, Buronga NSW

#### INTRODUCTION

'Manilla' station is part of the Mid Anabranch Landcare Group. The Mid Anabranch Landcare group is located 100 kms north of Wentworth in the semi-arid rangelands of south western NSW. The group is made up of several properties covering an area of approximately 150,000 hectares. The group was formed in July 1990 to combat major land degradation issues in a co-ordinated manner with the aim of restoring properties to their full productive potential. The major land degradation issues are rabbits and the encroachment of dense patches of woody weeds onto good grazing country. Narrow leaf hopbush (*Dodonaea attenuata*) and Turpentine (*Eremophila sturtii*) are the main problem. Other woody weed species are also present such as Punty bush (*Cassia eremophila*), Silver Cassia (*Cassia artemisioides*) and Scotia bush.

#### **METHOD**

Investigation of various methods of woody weed control have been trialled by the group in a project jointly funded by the landcare group members and NRMS. Techniques trialled to date include;

- Bladeploughing only (\$19-\$26)
- \* Bladeploughing followed by fire (\$19-\$26 + \$1.60)
- \* Bladeploughing followed by medic pasture establishment (\$19-\$26 + \$1.30)
- Bladeploughing followed by cropping and medic pasture establishment (\$10.95)
- Bladeploughing followed by cropping and lucerne pasture establishment (\$10.95)
- Chaining followed by fire (\$15)
- Chaining followed by bladeploughing (\$15 + \$19)
- \* Rabbit control was also trialled (\$6 per warren).

NB. Figures in brackets are approximate net costs per acre.

#### **RESULTS**

Bladeploughing was very successful as an initial treatment, although it was expensive. In paddocks with small areas of dense woody weed, bladeploughing is definitely a viable option to prevent future spread of woody weeds and subsequent loss of production. Follow up control of seedlings is a high priority. Management burning or follow up cropping (where viable) appear to be the best methods. Trials of both these methods are continuing. The rabbit control showed tremendous results. Ripping of warrens resulted in growth of speargrass, medics and bluebush on areas that have had no pasture growth for many years.

## FURTHER WORK ON 'MANILLA'

The success of the trials encouraged Mark to undertake further work in a paddock adjacent to the trial paddock on 'Manilla'. On 13 October 1992 the paddock was inspected by Western Lands and Soil Conservation Service staff for a once-off cultivation licence for woody weed control covering 425 hectares (1050 acres). In November 1992 Mark purchased a half share in a Pederick Stickrake. Blade ploughing of dense shrubs was performed using a D6 Bulldozer and a Stationmaster Bladeplough. Areas of small scattered hopbush were ploughed using a 5 gang Noble Bladeplough pulled by a 220 HP Case Tractor. The ploughing was completed in December 1992 at a total cost of \$20,230 (using contractors). Rabbit warrens were ripped at this time. Good rain fell in January 1993 providing good subsoil moisture.

Stickraking began on the 10th of February 1993 and 570 acres of the paddock were windrowed. Most of the windrows were burnt on the 26th February. In early March the 570 acres of stickraked land were worked using the Noble Bladeplough to prepare for crop in the first year. Follow-up warren

ripping was also done at this time. A Shearer Field Span was used for the final working and cleaning up of remaining scattered sticks.

On the 1st of June 1993 Condor wheat was sown @ 30 lbs/acre with 23 lbs/acre of MAP fertiliser. The crop was sown under dry conditions and resulted in Red Brome grass competing with large areas of the crop. The crop yielded 5 bags/acre and it was noted that in areas where hopbush had been thickest, the yield was considerably higher than the paddock average.

Gross margin analysis of the project to date using contract rates for machinery hours shows a loss of \$8.85 per acre. The bladeploughing cost an average of \$19.23 per acre and cost recovery from the crop was \$10.38 per acre. Note that costs refer to the 570 acres cropped so far, the remaining 480 acres are to be cropped this year.

## RESULTS ON 'MANILLA'

To date the advantages of the project are a clear paddock with very few rabbits. The costs have been \$8.85 per acre for the area cropped. After the remaining 480 acres are cropped the total cost of the project will be known. Medics are to be sown which will cost about \$1.30 per acre. The expected result will be an open paddock with a good pasture mix of native grasses and medics, and a return to full production.

# HOME STUDY COURSE PASTORAL PROPERTY MANAGEMENT IN WESTERN NSW

## Megan Withey

Project Officer, Murrumbidgee College of Agriculture, Yanco NSW 2703

Murrumbidgee College of Agriculture (NSW Agriculture) is currently developing a home study course on "Pastoral Property Management in western NSW". The project is funded by the National Landcare Program and is to be completed by December 1995.

Murrumbidgee College of Agriculture is one of two colleges run by NSW Agriculture. It is situated at Yanco in southern NSW on the edge of the Western Division.

The college has run a full-time Pastoral Property Management Advanced Certificate course for four years.

Whereas the full-time course is aimed at young people wanting to work in the pastoral industry, the home study course is for managers of properties. It may however appeal to Landcare groups or to individuals wanting to become more involved in the management of a property.

A draft outline of the course is given below. Module one has been completed and is being piloted. The remaining modules are in no way fixed and may be modified as a result of industry comments.

#### **COURSE AIM**

To encourage and assist those responsible for pastoral property management in western NSW to effectively manage their resources in a sustainable and profitable fashion.

#### DRAFT OUTLINE

#### Module 1: Resource Inventory

In this module the manager looks at the resources available on the property, including regional, physical, economic, personal and family resources. The aim of this module is to look at the constraints on the current enterprise as well as its current status.

#### Module 2: Animal Production

This module aims to encourage managers to look at their options for improving the performance of their enterprise while ensuring long term physical and economic viability. For each option there are strategies and tactics which will vary depending on the property. This module also looks at options for alternative enterprises and marketing.

## Module 3: Vegetation Management

Most options covered in Moduie 2 involve quality and continuity of feed, on which all animal production depends. This module expands the subject and looks at better utilisation of available land, forage composition, grazing management and total grazing pressure. Native and feral animal control is part of this module. This module aims to enable managers to develop a grazing strategy for their property.

## Module 4: Drought Planning

Living in such a variable climate, drought is a fact of life. Pasture and vegetation must be managed for recovery and so must finances. This module looks at drought strategies and also at reducing risk.

#### Module 5: Station Plan

In this module the manager looks at short, medium and long term plans. These involve improving the performance of the enterprise, caring for the land, financial management as well as personal and

family goals. Costing out planned improvements and setting priorities are important parts of the process; the plans then being implemented, monitored and reviewed regularly by the manager.

#### **GENERAL**

The course will not attempt to present all information on the subject. It will be more of a resource manual offering an approach to problem solving and planning and directing landholders towards sources of further information. Case studies of landholder experiences will be recorded on audio tape. A steering committee of landholders and government officers is advising the project officer compiling the material, though further comment from landholders and interested individuals or groups would be most welcome.

For further information, or copies of the report on consultation with Western Division landholders and government officers undertaken in September 1993, please contact the author (Phone: 069 530257, Fax: 069 530200).

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## MABO, IMPLICATIONS FOR LAND MANAGEMENT

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The views expressed in this paper are those of the author and not of the Northern Territory Government

#### INTRODUCTION

Since the High Court decision in Mabo v Queensland (Mabo v. Queensland [No.2] [1992] 175 CLR 1) there have been four distinct phases in the native title debate. Firstly there was the period when commentators, public policy practitioners, academics and Aboriginal groups tried to come to grips with the implications of the decision. Essentially, how should the common law recognition of antecedent native title be recognised by the statutory law? This period lasted until December 1992.

The second phase, consultation by the Commonwealth with state and territory governments, and Aboriginal and industry representatives, proceeded with the establishment of an interdepartmental Commonwealth team and lasted until around September 1993. The Aboriginal representatives will argue they were largely excluded from this process or at least their interests were not properly taken into account. Immediately following, there was a third phase when the Prime Minister personally took command and negotiations were carried on with the Aboriginal representatives. Although some peak industry groups were involved, state and territory governments were excluded from this phase which resulted in the passage of the Native Title Act through the Commonwealth Parliament in December 1993.

The fourth phase is now taking place and perhaps is best exemplified by the title of a recent conference: Working with the Native Title Act: Unravelling the Native Title Act and the fact that native title is on the agenda for this conference.

## WHAT IS NATIVE TITLE?

Native Title is not a title *per se* as generally understood in the Australian legal system. Rather, native title comprises rights exercised in accordance with Aboriginal tradition and which now constitute a legally enforceable right. The Act (1993) defines native title as:

"The expression 'native title' and 'native title rights and interests' means the communal, group or individual rights and interests of Aboriginal peoples or Torres Strait Islanders in relation to land or waters where:

- (a) the rights and interests are possessed under the traditional laws acknowledged, and the customs observed by the Aboriginal peoples or Torres Strait Islanders: and
- (b) the Aboriginal peoples or Torres Strait Islanders, by those laws and customs, have a connection with the land or waters; and
- (c) the rights and interests are recognised by the common law of Australia."

It is generally accepted that native title has been extinguished over most of Australia by past sovereign action inconsistent with the exercise of native title rights. Those rights may also be lost by the abandonment of traditional laws and customs.

## **NATIVE TITLE ACT 1993**

The Act establishes the National Native Title Tribunal with procedures for the filing of claims for both determination of native title and compensation. It also validates past Commonwealth actions and enables the states and territories, subject to conditions, to validate their own past actions. Administrative actions by Government in relation to land are defined as past or future and as permissible or non permissible. The Act itself does not validate past actions in a state or territory

although in the Northern Territory the Commonwealth's past actions until 1 July 1978, that is for the period prior to Self Government - are so validated.

## The Northern Territory Legislative Response

The Northern Territory took the first legislative action in March 1993 when the Legislative Assembly passed the Confirmation of Titles (Request) Act although it was never commenced. Basically this was a request to the Commonwealth to validate land titles in the Northern Territory and to accept the responsibility for compensation for extinguished native title. Although of no obvious practical effect, it served the political purpose of focusing the Commonwealth's attention on some of the issues that needed to be addressed.

In March 1994 the Legislative Assembly passed the Validation of Titles and Actions Act 1994 and then a series of complementary Bills in May of 1994 (Mining Amendment Bill 1994, Land Acquisition Amendment Bill 1994, and Native Title (Consequential Amendments) Bill 1994). The Northern Territory has chosen not to establish a native title tribunal leaving this field to the National Tribunal. It has however reconstituted the Land Acquisitions Tribunal and the Mining Warden as 'arbitral bodies' to deal with issues of compensation and the 'future permissible acts' regime in accordance with the Commonwealth legislation. Neither of these bodies will have a role in determining native title.

## **Some Practical Northern Territory Experiences**

Early in phase two of the Mabo response, the Commonwealth and Territory Governments were keenly aware of the potential impact of native title on two major mining projects that figured prominently in the Prime Minister's "One Nation" statement - Mount Todd and McArthur River.

In the case of Mount Todd, the area on which the mine is located being subject to repeat land claim under the Aboriginal Land Rights (Northern Territory) Act 1976, the claimants, represented by the Jawoyn Association, contracted to withdraw the land claim and to forgo any native title in exchange for a statutory freehold grant and certain other considerations.

Native title became a cause for dispute in the negotiations over the McArthur River project. In this case the land on which the project was located was not vacant Crown land but on a pastoral lease. In the view of the Northern Territory, any native title that may have existed had been extinguished by the prior grant of the pastoral lease - bearing in mind these negotiations took place some six months before the Commonwealth enacted its legislation. As a consequence, the Territory amended the McArthur River Mine Agreement Ratification Act to validate the mineral leases and exploration licences and to allow time for native title claimants to demonstrate the continued existence of native title and to claim compensation. This amendment resulted from a written request by the Prime Minister. Contrary to the views of many commentators at the time, the amendment did not of itself extinguish native title. However the Commonwealth legislated to provide that the non-extinguishment principle applied to these validated leases and licences (Native Title Act 1994 s.46).

The Commonwealth legislation allows for "non-claimant" applications to the National Native Title Tribunal for the determination of native title (Native Title Act 1994 s.67[1]). The Territory has lodged two such applications. One relates to a narrow strip of land within the central business district of Palmerston that seems to have never been alienated and therefore native title not extinguished. The other relates to the proposed suburban development of Roseberry, a development critical to the future growth of Darwin. Again the land seems to have not been alienated and therefore no prior grant of title sufficient to extinguish native title. Such actions should not be construed as somehow in opposition to the concept of native title. The Commonwealth act specifically provides for such actions in the interest of seeking certainty in land administration.

## **Pastoral Leases**

Brennan in his leading judgement (Mabo v Queensland 175 CLR 1 at 69 per Brennan J) said:

"Where the Crown has validly alienated land by granting an interest that is wholly or partially inconsistent with a continuing right to enjoy native title, native title is extinguished to the extent of the inconsistency. Thus native title has been extinguished by grants of estates of freehold or of leases but not necessarily by the grant of lesser interests (e.g. authorities to prospect for minerals)."

In addressing this principle, the Act defines a "category A past act" to include a pastoral lease (Native Title Act 1993 s.229[3]) that is able to be validated. This being the case, it would seem that with the volume of land being pastoral lease or Aboriginal land (or at least subject to claim), that there is very little land left that could be subject to native title. Most analysts agree that pastoral leases do extinguish native title but that matter is not free from doubt. One legal firm (Blake Dawson Waldron Mabo and the Native Title Act 1993: The Commercial Perspective p.28) states:

"The Act failed to rule out the possibility that the reservations and conditions applying to pastoral leases in Western Australia, the Northern territory and South Australia result in the preservation of Native Title. Until the issue is conclusively resolved, uncertainty continues."

"Native title rights and interests" includes hunting, gathering, or fishing rights or interests (Native Title Act 1993 s.223[2]) and other statutory rights and interest in land or waters held by Aboriginal peoples or Torres Strait Islanders (Native Title Act 1993 s.223[3]) but does not include rights or interests created by a reservation or condition in a pastoral lease granted before 1 January 1994 (Native Title Act 1993 s.223[4]). It seems therefore that generally pastoral leases in the Northern Territory are able to be validated and that native title has generally been extinguished. However land administrators will not be able to proceed with confidence until some precedent is established under the new legal regimes.

## Aboriginal Owned Pastoral Leases and the National Land Acquisition Fund

Under the Commonwealth Land Rights Act applying in the Northern Territory, Aboriginals are able to make a traditional land claim to alienated Crown land in which all estates and interests not held by the Crown are held by, or on behalf of, Aboriginals (Aboriginal land Rights (Northern Territory) Act (Cth) s.50[1]). By this means pastoral properties are able to be purchased, claimed and, subject to the Land Commissioner's findings, granted as 'inalienable freehold' pursuant to the Act. In this case, the Pastoral Land Act and the conditions of the prior pastoral lease no longer apply. Therefore there remains considerable doubt as to whether the other laws of the Northern Territory apply to Aboriginal land not withstanding another provision of the Act (Aboriginal land Rights (Northern Territory) Act s.74 "Application of laws of Northern Territory to Aboriginal land").

The Native Title Act 1993 avoids this issue in a positive way. Under this Act the National Land Acquisition Fund can be accessed to purchase a pastoral lease and not withstanding any previous actions now validated, claimed as native title land. On a successful application, the determination of native title does not affect the validity of the lease (Native Title Act 1993 s.47[3]). This, coupled with the general provision as to the application of state and territory laws (Native Title Act 1993 s.8 "Effect of this Act on State or Territory Laws" seems to ensure the application of Northern Territory land law in a way that the Land Rights Act does not. This difference is a key factor in the political stance taken by the Territory Government on the whole issue of Aboriginal land rights.

## Mining

The Native Title Act 1993 provides a complex regime to handle the issue of exploration licences and mineral leases over native title land. Ostensibly there is no veto as exists in the Land Rights Act but a "right to negotiate" although the mining industry will argue that the criteria to be considered by an 'arbitral body' is weighted in favour of the "native title party". Where the native title parties are objecting to the grant of a mineral interest, any adverse impact on their interest will need to be outweighted by "...the economic or other significance of the proposed act to Australia and to the State or Territory concerned..." (Native Title Act 1993 s.39[1]). Those familiar with similar arguments in Coronation Hill will appreciate the concern of the industry.

The mining provisions under the *Native Title Act* are disjunctive and there is a positive incentive for the proponents to enter into agreements with the native title parties based on payments worked out on profits, income and production (*Native Title Act 1993* s.38[2]). However the Arbitral Body is not able to insist on such payments in the absence of an agreement.

## **Implications for Land Administrators**

It is commonly said among Territory land administrators that "we have either got a big issue to deal with or a little one" and this turns on the question of validity of pastoral leases. However there will be other 'spin off' effects from Mabo and whether these will be good or bad depends on your particular perspective.

For the immediate future, any land administration decisions will need to be made on a 'risk assessment' basis until there is sufficient body of precedent to clarify all of the issues that arise in the exceedingly complex Native Title Act. Administrators in the Northern Territory should already be thoroughly familiar with the Aboriginal Land Rights (Northern Territory) Act 1976 (Cth), the Northern Territory Sacred Sites Act and the Aboriginal and Torres Strait Islander Heritage Protection Act in addition with the specific legislation with which they already work. They will now need to add a further string to their bow - the Native Title Act 1993.

Risk assessment depends on having access to accurate title data including the tenure history of any land under consideration. Additionally, persons compiling a native title application are required to provide a level of detail and will depend on the records of government. In the Northern Territory, the Department of Lands, Housing and Local Government has had to establish a special task force to handle the inundation of requests for tenure searches.

The common law recognition of native title rights will have other significant impacts. Aboriginal people will no doubt look more closely at arguing the preservation and exercise of their statutory rights found in pastoral, conservation and fishing legislation to achieve a greater level of economic participation. For example, the development of pastoral properties by fencing and pasture improvement or by the excision and conversion of areas to other forms of title may have the effect of inhibiting the exercise of the rights contained in the reservation to pastoral leases.

There now appears to be greater emphasis given to the productive management of existing pastoral holdings. Certainly the Commonwealth has recognised the difficulties that have arisen in connection with the Land Rights Act in this regard. It is expected that a greater proportion of the National Land Acquisition Fund will be spent in addressing the land needs of Aboriginal people in southern Australia who are no longer able to demonstrate native title through continuing traditional attachment and where little vacant Crown land remains. However there is no doubt there will be a concerted lobby to supplement the available funds from the Aboriginal Benefits Trust Account to purchase land in the Northern Territory ahead of the 1997 land claim sunset.

Understanding these issues is not just about developing familiarity with legislation. It is also necessary to gain an appreciation of Aboriginal history, Aboriginal culture and contemporary Aboriginal politics. The High Court decision in *Mabo v Queensland* and the subsequent enactment of the *Native Title Act 1993* brings a whole new dimension to land administration in Australia.