ISSN 1323-6660

Australian Rangeland Society

13th Biennial Conference
Alice Springs 5th - 8th July 2004

"Living in the Outback"

Conference Papers

AUSTRALIAN RANGELAND SOCIETY
13^{th} BIENNIAL CONFERENCE

"LIVING IN THE OUTBACK"

CONFERENCE PAPERS

ALICE SPRINGS, NORTHERN TERRITORY
5 – 8 July 2004

Edited by Gary Bastin, Dionne Walsh and Sarah Nicolson

SPONSORS

The Conference Committee for the 13th Biennial Australian Rangeland Society Conference acknowledges the generous sponsorship provided by:

Department of Agriculture, Fisheries & Forestry

NT Department of Infrastructure, Planning & Environment

Department of Environment & Heritage, Canberra

NT Department of Business, Industry & Resource Development

Desert Knowledge CRC

Rangelands Australia

Land & Water Australia

Alice Springs Town Council

Elders

CSIRO • Centralian Land Management Association • Low Ecological Services P/L

WELCOME

Welcome to the "Living in the Outback" Conference, the 13th Biennial Conference of the Australian Rangeland Society. This is the 3rd conference to be held in the NT and I hope that you find it as useful and stimulating as the last two.

"Living in the Outback" follows on from the conference two years ago in recognising the increasing diversity of uses and users which must be managed and catered for in the Rangelands. We have moved a few steps forward in integrating the multiplicity of facets impacting on Rangelands and recognise that there will always be a need for dialogue between users in order for management of these robust yet sensitive lands to progress. We have learned a lot over the many years since livestock were brought into the land and I feel we are in the exponential phase of gaining management information and technology. The large quantities of information that need to be assimilated in order to get a sustainable result place an increasing burden on all of us. In these even more trying times of global warming, overcoming the risks requires that we must also be adaptable. I hope that during the coming week you will put in as much information as you take out.

The organisation of this Conference has been slightly easier because of the desire of the general scientific and government community in Alice Springs to make this a good one and because of the experienced and enthusiastic Conference Committee that has provided the energy, drive and direction to pull it together. Dionne Walsh has managed to keep us all up to date with superb organisational and communication skills. Gary Bastin has been a driving force to be reckoned with in organising the program and getting the papers together. The rest of the committee, Alison Kennedy, Christine Edgoose, Coral Allan, Greg O'Reilly and our primiparous Katherine member, Robyn Cowley, were a pleasure to work with. Sarah Nicolson, our professional conference organiser, has provided dedicated commitment, guidance and information based on her growing experience with previous conferences. The enthusiasm of the Committee has been inspiring.

I also want to thank most gratefully the Session coordinators who were dragged into organising the sessions. Their response, expertise and contacts facilitated the development of the program.

Organisation has also been easier with the ready financial sponsorship provided by our major sponsors: Department of Agriculture, Fisheries and Forestry and Department of Environment and Heritage (Australian Government); NT Department of Infrastructure, Planning and Environment; NT Department of Business, Industry and Resource Development; and the newly formed Desert Knowledge CRC. The sponsorship from Rangelands Australia, Alice Springs Town Council, Elders and Land and Water Australia has also provided additional opportunities for bringing together a diversity of land managers and students. The host organisations that we work for have been magnificent in providing sponsorship in kind, this includes the NT Departments above as well as the Centralian Land Management Association (CLMA), CSIRO and Low Ecological Services.

I wish you a pleasant stay in Alice Springs, and an informative and productive week during the 13th Conference of the Australian Rangeland Society.

Bill Low, Chair Conference Organising Committee.

CONFERENCE ORGANISING COMMITTEE

Bill Low (Chair)

Gary Bastin

Dionne Walsh

Robyn Cowley

Alison Kennedy

Coral Allan

Greg O'Reilly

Christine Edgoose

CONFERENCE COORDINATION

Intercomm Event Coordination (Sarah Nicolson)
22 Edmund Ave, Unley SA 5061
Mob. 0419 815 864

Disclaimer:
Every effort has been made to ensure the editing and formatting of papers included in the Conference Papers is in accordance with the author's instructions, however there may be some errors for which the Editors apologise.

CONFERENCE PROGRAM

Sunday 04 July 2004 – Minnimurra Hall, St Philips College

5pm – 8:30pm	Registration and Civic Reception, hosted by Her Worship the Mayor of Alice Springs (**Ms Fran Kilgariff**)

Monday 05 July 2004 – Minnimurra Hall, St Philips College

7:30am	Registration desk open
8:45am	***Convenor:*** **Bill Low**, Chair Alice Springs Conference Committee
	Welcome to Country – Lhere Artepe Aboriginal Corporation
	Official opening: His Honour, the Administrator of the Northern Territory, **Mr Ted Egan AO**
9:15am	**KEYNOTE ADDRESS:** "Developing a knowledge base for sustainable outback living"
	Mr Paul Wand, Chairman of the Board, Desert Knowledge Cooperative Research Centre
10:00am	***Morning tea***
10:30am	**ENVIRONMENTAL RISK MANAGEMENT**
	Convenors: **Gary Bastin** (CSIRO) & **Peter O'Reagain** (Queensland Dept of Primary Industries & Fisheries)
	"A review of eight major degradation episodes in the history of Australia's rangelands – can we prevent the ninth?" (**Greg McKeon**, Queensland NRM&E)
	"Australian rangelands: managing the risks of climate change" (**Mark Howden**, CSIRO)
	"Fragmentation of Australian rangelands: risks and trade-offs for land management" (**Chris Stokes**, CSIRO)
	"Precision pastoralism – the key to environmental risk management" (**Tony Thompson**, Afterhours Ag)
	"Policy contributions to environmental risk management – matching policy to the rangeland environment" (**Ron Hacker**, NSW Agriculture)
12:30pm	***Lunch***

CONFERENCE PROGRAM

1:30pm	**ECONOMIC AND SOCIAL RISK MANAGEMENT**
	Convenors: **Dionne Walsh** (Centralian Land Management Association) & **Merri Tothill** (University of South Australia)
	"Proactive risk management – the South Australian approach" (**Jim Cawthorne**, Rural Solutions SA)
	"Human drivers influencing change in the Upper Gascoyne and Mt Magnet regions of Western Australia" (**Lynda Braddick,** Murdoch University)
	"People: the most important element for environmental integrity in the rangelands" (**David Lord**, Thackaringa Station, NSW)
	"Ensuring employment opportunities in the rangelands of Australia" (**Carmel Wagstaff**, Australian Agricultural Company)
	"Ecological and economic renewal of rangeland production systems" (**Terry McCosker**, Resource Consulting Services)
3:00pm	**SPONSOR PRESENTATION** - Department of Agriculture, Fisheries & Forestry (**Warwick Jones**)
3:10pm	***Afternoon tea***
3:40pm	Formal poster viewing session
5:00pm	**BOOK LAUNCH** "Healthy Rangelands: Biophysical Principles for Sustainable Systems in the Burdekin" (**Stephen Smith**)
5:30pm	Buses depart to hotels and then to dinner venue
6:30pm	BBQ at the Alice Springs Golf Club

Tuesday 06 July 2004 – Minnimurra Hall, St Philips College

7:30am	Registration desk open
8:30am	**SHOWCASING & POSITIONING THE NEXT GENERATION**
	Convenors: **Robyn Cowley** (NT Department of Business, Industry & Resource Development) & **John Taylor** (Rangelands Australia/University of Queensland)

Student Presentations:

Mulga (*Acacia aneura*) death adjacent to haul roads in the northern goldfields, Western Australia (**Muriel Bertuch**, Edith Cowan University)

"Climatic place: a socio-cultural geography of climate risk management" (**Peat Leith**, University of Tasmania)

"An introduction to the gypsophilous vegetation of semi-arid and arid south-eastern Australia" (**Marion O'Keefe**, University of Ballarat)

"Rangeland monitoring with MODIS 250m data" (**Kate Richardson**, NT DIPE)

"What's in a photograph? A comparison of photographic and field measurement techniques for monitoring sites in the southern rangelands of Western Australia" (**Peter Russell**, Centre for the Management of Arid Environments)

"Aboriginal perspectives on the kangaroo industry in South Australia: an introduction to current research" (**Dana Thomsen,** University of Adelaide)

Keynote Address: "Positioning yourself for a future in the rangelands" (**John Taylor**, Rangelands Australia)

Successful Young Managers Presentations:

"Keeping young people in the rangelands" (**Justin Dyer**, Hayfield Station, NT)

"Multiple pathways to success in land management" (**Jenny White**, Australian Agricultural Company)

Facilitated Panel Discussion: "Retaining young people in the rangelands and the transition from education to work in the rangelands" **Panel members: Tim Ferraro, John Taylor and Carmel Wagstaff**

10:30am ***Morning tea***

11:00am **BUSINESS SYSTEMS (SPONSORED BY THE DESERT KNOWLEDGE CRC)**

Convenors: **Murray McGregor & Mark Stafford Smith** (Desert Knowledge CRC)

"Why are chains important?" (**Murray McGregor**, Curtin University & Desert Knowledge CRC)

"The "wise" supply chain: knowledge as a component of its success" (**Denise Hart**, Rangelands Australia)

"Making supply chain management work – Robins Foods case study" (**Juleigh Robins**, Robins Foods Pty Ltd)

"Making supply chain management work – case study OBE Beef" (**Peter Schmidt**, OBE Beef Pty Ltd)

12:30pm	***Lunch***
1:30pm	**INDIGENOUS LAND MANAGEMENT** *Convenors*: **Jocelyn Davies** (CSIRO & Desert Knowledge CRC) & **Sandy Marty** (Central Land Council) **Keynote Address:** "Achievements and challenges for indigenous people in Australian rangelands" (**David Ross**, Central Land Council) "For healthy country and healthy people: indigenous land management in Central Australia" (**Jocelyn Davies**, CSIRO & Desert Knowledge CRC) **Panel Discussion:** Indigenous people will talk about their approaches to land management – their current practices, aspirations, achievements and challenges. The focus will be on the diverse land uses and cultures across the substantial proportion of Central Australia where indigenous land ownership is now recognised; illustrating how these approaches support biodiversity conservation and regional economic empowerment, and highlighting partnerships between indigenous land owners and land management support services. Traditional owners and other land managers from Anangu Pitjantjatjara Yankunytjatjara Land Management, the Ngaanyatjarra lands in Western Australia, Arrernte country around Alice Springs, pastoral stations in South Australia, the Tanami Desert and Uluru-Kata Tjuta National Park will contribute to this discussion.
3:30pm	***Afternoon tea and formal poster viewing session***
5:00pm	Depart conference venue for Conference Dinner at Ooraminna Bush Camp

Wednesday 07 July 2004 – Minnimurra Hall, St Philips College

8:00am	Registration desk open
8:30am	Field tours depart from the Conference venue
Evening	Delegates arrange own meals after tours

CONFERENCE PROGRAM

Thursday 08 July 2004 – Minnimurra Hall, St Philips College

8:00am	Registration desk open
8:30am	General Meeting of the Australian Rangeland Society (everyone is welcome)
9:45am	**BIODIVERSITY MANAGEMENT**
	Convenors: **Anita Smyth & Gary Bastin** (CSIRO)
	Keynote Address: "Biodiversity monitoring in rangelands" (**Craig James**, CSIRO & Desert Knowledge CRC)
	"Land condition" as a surrogate for biodiversity health in tropical savanna rangelands" (**Alaric Fisher**, NT DIPE)
10:35am	**SPONSOR PRESENTATION** – NT Government, Department of Infrastructure, Planning & Environment
10:45am	***Morning tea***
11:15am	**BIODIVERSITY MANAGEMENT continued**
	"Ants as indicators of the impact of perennial shrub loss in chenopod shrublands of semi-arid southern Australia" (**Sylvia Clarke**, University of Adelaide)
	"Biodiversity monitoring or biodiversity management systems: which is the cart and which is the horse?" (**Hugh Pringle,** Centre for the Management of Arid Environments)
	"Integrating historical datasets to prioritise areas for biodiversity monitoring?" (**Anita Smyth**, CSIRO)
	"Practical biodiversity" (**Bob Purvis**, Woodgreen Station, NT)
	Synthesis (**Anita Smyth**, CSIRO)
12:40pm	***Lunch***

CONFERENCE PROGRAM

1:30pm	**MULTIPLE USE & MULTIPLE USERS**
	Convenor: **Margaret Friedel** (CSIRO)
	Keynote Address: "Multiple use, multiple values – greater than the sum of the parts" (**Kate Andrews**, Land & Water Australia)
	"*Acacia peuce*: a case study in co-operative management" (**Joanne Bloomfield**, Andado Station, NT & **Amanda Markham**, NT DIPE – Parks & Wildlife Service)
	"Enterprise based conservation – conservation as a commercial land use" (**Ed Fessey**, "Bullabelalie", NSW)
	"Tourism as a driver for regional growth and diversification" (**Romy Greiner**, CSIRO)
	"Multiple and joint uses on pastoral leases: tenure reform to accommodate the multifunctional transition" (**John Holmes**, University of Queensland)
3:00pm	***Afternoon tea***
3:30pm	**PLENARY SESSION**
	Convenor: **Bill Low** (Chair Alice Springs Conference Committee)
	Summary of Conference (**Andrew Ash**, CSIRO)
4:30pm	**CONFERENCE CLOSE (Bill Low)**

CONTENTS

Page

Monday, 5 July 2004

Tuesday, 6 July 2004

SHOWCASING & POSITIONING THE NEXT GENERATION

BUSINESS SYSTEMS

INDIGENOUS LAND MANAGEMENT

Page

Contents pages for:

DEVELOPING A KNOWLEDGE BASE FOR SUSTAINABLE OUTBACK LIVING

Paul Wand and Mark Stafford Smith

Desert Knowledge Cooperative Research Centre, PO Box 2111, Alice Springs, NT 0871

ABSTRACT

The future of outback Australia depends on the creation of new regional economic development opportunities. We argue that these are likely to be based on a new approach to valuing our current or prospective industries and related livelihoods, branding them under a single concept as desert Australian products, with an emphasis on the 'desert knowledge' embedded in their production. We follow the issues that would arise from the decision to take this approach through to the consequent R&D needs. There are key features of inland Australia which must be taken into account in this analysis; these reach beyond natural resources to all aspects of life in desert regions, but paint a picture of some extraordinarily positive opportunities for the future if we can take a collaborative approach to their development across desert Australia.

INTRODUCTION

This conference is mainly about managing natural resources. We argue, though, that there will be no management of the natural resources of inland Australia if managers don't want to live there; and they won't want to live there if there is no livelihood to be had or conditions are too harsh to be tolerated. However, we say this as a matter of exciting opportunity, not of despair! The recently developing ideas behind 'desert knowledge' specifically aim to address this issue.

The general concept of Desert Knowledge emerges from three observations – two negative, but the third very positive, albeit creating a further quandary:

a) Outback Australia faces many pressures and problems, and potentially greater ones in the future. On the one hand there are declining levels of services in remote centres, with many smaller towns shrinking; on the other hand the work-aged Indigenous population is expected to grow by a third over the next 15 years (Taylor 2003), in the face of massive unemployment and related social disharmony.
b) It is also a reality that there has been no quantum change to the economy of inland Australia in the 20, 50, or even 100 years. It is narrowly founded on mining, pastoralism and government services, with only the addition of tourism in recent decades. All of these are susceptible to external forces, whether terrorist attacks, resource prices or distant policy priorities. Thus the solution to the first point currently must be found from a narrow and fragile economic base.
c) Yet if you watch people living out here, innovation and local knowledge abounds everywhere, from the builder who can put down a concrete block without it cracking on a 45°C day, to the Indigenous knowledge about bush plants and animals, to contractors who can transport a remote area power supply out across 500 km of corrugated roads without destroying it then install it so that it doesn't fail in the first dust storm, to the health clinic that knows how to support staff and patients in an inhospitable medical environment, to the pastoralist who can target a patch of woody weeds with a well-controlled management burn. Although we don't do it perfectly, there is this immense store of knowledge about how to live well in remote desert environments.

The quandary is that no single one of these examples is going to make the silver bullet, single focus export industry which solves the problems of livelihoods in inland Australia. But if we stand back from the individual bits of knowledge and ask what they are all about, *living sustainably and harmoniously whilst creating wealth in desert regions*, then we have a collective commodity that can be developed, used, marketed and exported. This is essentially the vision of *Desert Knowledge.* Inland regions could benefit in three general ways:

- Immediately and locally, by improving the quality of life in desert Australia through the better use and exchange of these ideas. But this alone won't bring new money into the economy.
- Identifying a (probably small) subset of the knowledge which could be used in international markets (or at least markets outside desert Australia) as a real export.
- Establishing such a good reputation that people are attracted to come to desert Australia, both to live in the long term, and to visit for education or as tourists as a result of that exciting, knowledge-based reputation.

Over the past five years, several organisations have been established or refocused their activities to support this vision. The movement is led by Desert Knowledge Australia, established in Alice Springs but with membership now across the continent, which has a focus on promoting the idea and creating the networks needed to implement it. One spin-off effort from this has been the creation of the (independent but closely aligned) Desert Knowledge Cooperative Research Centre (DK-CRC), with a mandate to pursue research-oriented aspects of the vision. Essentially, this is in recognition of the fact that the Desert Knowledge idea needs to be backed by a new *"Science of Desert Living"*.

DK-CRC argues that we need to work towards these four outcomes:

- Sustainable livelihoods for desert people based on new natural resource and service enterprise opportunities that are environmentally and socially appropriate.
- More viable remote desert communities to support the presence of desert people, as a result of facilitating access to more attractive services that are delivered more efficiently.
- Thriving regional desert economies that are based on unique desert knowledge and which are more self-sufficient.
- Increased social capital of desert people, their communities and service agencies.

But what are the areas of science needed to back all this up – what is the niche that this new science must fill and on which it must capitalise?

DRIVERS

We must first address the term *'desert'* – some people are uncomfortable with labelling all of inland Australia as desert. We need to be clear that it is being used as a marketing term for those regions sharing the characteristics of low and uncertain primary productivity, low and dispersed populations, poor infrastructure, and significant Indigenous interests. This more-or-less corresponds to the modern usage of the term 'rangelands' (i.e. where the usage is not seen as limited to grazing), but 'rangeland knowledge' (let alone 'arid and semi-arid knowledge') was judged a poorer brand name!

These underlying characteristics bear with closer examination:

- *Variability*: we are accustomed to talking of inland Australia as possessing one of the genuinely most variable climates in the world, a characteristic it shares to a various degree in different regions with other southern hemisphere semi-arid areas. Less uniquely, it is also subject to variability driven by distant markets, and by policy-making processes which are directed mainly towards people and conditions nearer to the coast and which are split between at least five state jurisdictions in this regard.

- *Settlement patterns*: remoteness and sparse population (and an indigenous desire to return to remote outstations) has created an unusual settlement pattern in desert Australia, which is still evolving. Population in the major service centres (like Kalgoorlie, Mount Isa, Broken Hill or Alice Springs) is about 100 times less than in the coastal cities (~1-3m to 20-30,000); there is generally another 100 times step from the service centres to the remoter communities (eg. 25,000 to ~100-500). This is quite different to the typical European experience, where settlement sizes are more continuous but in any case rarely step down by more than ten-fold. Other obvious differences are the typical physical distances between larger and smaller settlements, and the fact that a significant proportion of the smallest settlements were not located with regard to market access or conventional economic resources. This has huge implications for the relationships between these population centres, in terms of human capacity, internal competition, service costs, governance patterns, even social norms, which cannot rely on models that work in coastal Australia.
- *Aggregation and globalisation vs. regionalisation:* remote areas are on the receiving end of the tendencies towards social and economic agglomeration driven by critical mass and economies of scale. Given that globalisation forces are clearly speeding up this effect, investment decisions need to be made in full awareness of the degree to which they may be mitigating (or exaggerating) the rate at which this pressure to agglomerate proceeds, with its attendant implications for "fugitive capital" of all kinds. However, these economic forces are interacting also with current ideological and political forces towards de-centralisation and local empowerment, with the potential for some serious conundrums in terms of conflicts between economic and social efficiency if the implications of each are not understood (Stafford Smith *et al.* 2003).
- *Partnerships between Indigenous and non-indigenous people:* desert regions have the most intact surviving Australian Indigenous culture, and least alienated land rights. Plenty has been written about the often dire circumstances of these peoples. The essential point here is that the future of remoter Indigenous communities depends on the thriving persistence of the mainly non-indigenous service centres; but also that the future of the service centres is dependent on economic investment from Indigenous interests, as well as the development of industries based on Indigenous culture, among other opportunities. Thus the future of desert Australia depends on real partnerships among all desert peoples.

These features create a syndrome of characteristics for desert Australia which require special consideration, but which are not so different to the other 35% of the world's land surface that is desert that the solutions found here might not be valuable elsewhere (nor, indeed, that we would not learn by linking with them). The drivers also lead to some issues we must recognise and manage. After all, the population of 'desert Australia' exceeds half a million people (Taylor 2003), bigger than the Australian Capital Territory or Tasmania, yet whilst the latter both possess universities, seats of government and headquarters of major companies, the 70% of the continent that is desert Australia possesses none of any of these. This did not happen by chance – we need to understand why.

PROBLEMS, OPORTUNITIES AND RESEARCH NEEDS

Some key influences emerge to provide a coherent picture of the issues that a *Science of Desert Living* must tackle, moving from internal issues to those relating to interfacing with the rest of the world.

Data bases for a coherent view on the region that is 'desert Australia'

At present there are few statistics for which a coherent picture can be drawn of what is happening in desert Australia as a single region with common issues. Vegetation types (at management resolution) are defined in different ways on either side of state borders. Feral animals numbers are estimated with methods which mean that there appear to be major step-changes in populations at unfenced political boundaries. There is very little integrated information on economic flows in and out of remote regions, and none then collated at a desert-wide level. Very recently there is the beginnings of a desert-wide analysis of the education and training needs of inland Australia, through the work of Rangelands Australia for resource managers (Taylor 2002) and the Desert Peoples Centre for the special needs of Indigenous communities across the region. The Australian Collaborative Rangelands Information System (ACRIS) of the National Land and Water Resources Audit is also starting to address this issue for natural resources. Ironically, some of the more coherent services data is not in the long-established resource industries, but for Indigenous communities, where ATSIC has sought data over recent years, for example in their Community Housing and Infrastructure Needs Survey database, which identifies the ~860 remote Aboriginal communities – it is not possible to obtain similar statistics on non-Indigenous settlements. Although data collation may not be an exciting task, there is an urgent need for information which clarifies the common nature of issues across desert regions and thereby forms up "desert Australia"' as a coherent entity.

Variability, unpredictability, feedback and community learning

The natural environment, but also the economic and political environment, of people managing all sorts of resources in the rangelands is variable and largely out of the control of the desert dweller. This results in great variability over time, the major effect of which is to make it hard to detect whether a particular approach to management (of land, organisations, businesses, or whatever) is good or bad – the externally-driven noise always tends to overwhelm the signal that one is trying to monitor unless the monitoring continues for a long time, or it is based on proper adaptive management experimentation. Experiential learning is therefore hard – herein a role for science. But there will never be a great deal of scientific resources for so large an area so we'll always depend on local experience to ground the science – herein a vital role for local knowledge. In short, in deserts as nowhere else there is a critical need to develop new modes of engaging local (Indigenous and non-Indigenous) knowledge with the scientific method to create new approaches to efficient community learning (Lynam and Stafford Smith 2003). This engagement needs to be particularly around understanding the variability in all the aspects of our lives, whether biophysical, social, political or economic. Extending concepts of adaptive management, and developing ethical and effective ways of linking science with local knowledge, whether that of pastoralists, small businesses or Indigenous people, are vital areas for research.

Small communities, governance structures and statistics

One of the subtle forms of variability and unpredictability brought about by small populations is the sensitivity of outcomes to individual events (including individual people). Of course exceptional leadership drives outcomes in any size community, but at the level just below those extraordinary people, outcomes are greatly affected by whether there is a pool of supporting talent. In large communities there may be the same proportion of capable people at this level, but there will be 1000 individuals instead of 2; as a consequence the large community is statistically far more resilient to the loss of a few of those people. Perhaps more subtly, this issue extends beyond leadership – the smaller the governance unit the more susceptible it becomes to being disrupted by a single chance event of any type. For example, in a large community one death among 1000 hospital patients may create some bad press but (if there is no underlying structural problem) likely to be accepted as part of the chances that we must all take (0.1% risk). A remote clinic with only three beds may have the same long-term death rate, but one untoward death will appear as a 33% death rate at the time it occurs, which can create much greater disruption. Similarly a single incident of corruption, or wilful leadership, or personality clash, or just leader burnout, acquires a much greater significance in a small community than a large one. Of course, the contrary point is that a single person can make a much greater difference. All of this is expressed as a greater variability in these issues for desert communities than in large communities. The opportunity in this is that, even if innovation is as common in large communities as small ones (and we may argue that this is not the case), innovation is more likely to be able to surface in the small communities. Key research issues here are to enable communities to understand and find solutions to the issues raised by being a small community (solutions which may themselves be marketable knowledge), as well as to facilitate the emergence of innovation in these environments.

Critical mass and demand-driven services

One of the great tensions in governance structures is the debate about regionalisation and self-determination in obtaining a balance between genuine local (downwards) accountability and efficiency of service delivery. There is plenty of international research showing that ensuring communities have local accountability results in much better outcomes – it may take an election cycle or two to sort out mistakes and build local confidence, but eventually the local feedback loop is (re-)built and services become sensitive to local demand. However, as noted above, in small communities, there is often a lack of critical mass of skills and other resources, so there is always a tendency to need to agglomerate services into larger units for efficient delivery. What is the appropriate trade-off between these issues in different circumstances, and what institutional structures can be devised which perhaps allow accountability to operate at a much lower level than service delivery?

There are many other governance-related issues. In particular, the practice of regionalisation generally devolves responsibilities faster than it devolves rights and resources, setting small communities up to fail because they don't really control what they need to, or lack the financial and human resources to do what is being asked of them. On the other hand, desert Australia has been particularly embedded in a welfare mentality (however subtly) for much of its European history – whether in terms of drought support for producers or paternalistic policy towards Indigenous peoples. As a consequence, local communities can be too ready to take the rights and resources but not respond adequately to the responsibilities. Understanding how to change this culture is an essential component of re-thinking governance, local knowledge rights, and service delivery in these regions.

Agglomeration, social norms and linking to the rest of the world

The gravitational pull of larger urban centres for people, capital, political power, and even social norms (as marketed back out through media such as TV) is universal. In the past, remote areas have resisted it because communications were poor, and costs of transport were such that goods and services had to be provided locally. This is often no longer true except for specific activities (wherein the competitive advantages of the rangelands must be sought – see next section), and it is important that we understand this conflict between the economic pressures to agglomerate and the ideology of regionalisation, in order to steer regions away from some sterile lobbying (where economic realities will eventually crush action) and enable them to focus on capturing opportunities (where real competitive advantages exist).

Agglomeration has implications that extend far beyond simple economics. For example, there seem to be good theoretical reasons to expect that, left to their own devices, small communities will evolve different social norms for consultation and interaction than larger ones *(pers. comm.* Yiheyis Maru and Ryan McAlister, CSIRO). Small communities (like family units) often develop extensive interactions which sustain social relationships – a process illustrated most particularly in Aboriginal culture. As communities become bigger, extending this intensity of interaction to involve more and more people becomes increasingly costly and unsustainable, and communities create new mechanisms for interaction, generally requiring less time and perhaps more codification of outcomes in policies. Recent research shows that these effects can be simulated, and that when small communities interact occasionally with big communities, the interactions are driven by the social norms of the larger communities, leaving the small community feeling 'cheated' in terms of process. How often does one hear the country complain about Canberra bureaucrats not spending the time to understand the local problems, even whilst the latter are delivering substantial subsidies to the former? The point is that this may not be malfeasance on the part of central bureaucrats, but an *inevitable* outcome of our settlement patterns that we must learn to live with and manage, not simply rail against. The 100-fold difference in size between our service centres and hinterland communities only exacerbates this, and again creates a marketable knowledge opportunity.

Differentiating our product and a "post-productivist paradigm"

Given that we don't want to compete with the rest of the world on their own ground – globalisation will beat us at that – what should we be focusing on? Holmes (2002) has argued that outback Australia is moving from a 'productivist' (i.e. mining and grazing) driven past towards a 'post-productivist' future (i.e. based on its non-market values, particularly Aboriginal culture and welfare, and natural resource conservation), although he shows how different regions are doing this to different extents (Holmes 1997). Consider some examples. We can market "beef", or we can market "beef grown on natural pastures, managed to preserve their natural heritage and a rich diversity of forage sources and flavours". Likewise we can market "bush tomatoes", or we can market "bush tomatoes harvested from their natural desert environments by traditional Aboriginal women who benefit from their sale". We can even market "accessible gorge country", or we can market "central Australia ochre gorges containing palms that have been isolated for tens of thousands of years from their nearest relatives a thousand kilometres away and are carefully managed for their survival". In each case the first product will be competing in a market with many others, but the second – if established – cannot be taken away from desert Australia. Essentially we are seeking to imbue each product with a sense of embedded 'desert knowledge'; note that the actual product (as in the case of beef, above) may not be that much changed, but its marketing is focused on place – or culturally-based values; other products, like Aboriginal art and music, are quite different. There is research needed here not only to develop new products and services, but also to understand how to market them, and how to manage and monitor their environments and benefit sharing so that the marketing claims about sustainability and cultural harmony can be credibly substantiated.

Business networks and creating livelihoods

Finally, in this review of issues, it remains that businesses in desert Australia are small and dispersed, and often fiercely independent. Yet we know it is foolish to imagine that a one-person operator at Wiluna or Yuendemu can (a) afford the time to research and reach out to international markets, nor (b) assure the continuity of supply needed to sustain that marketing link. What are the models of business networks which enable people to remain as local competitors yet to collaborate in larger markets? There are examples of these in community art networks (DESART, http://www.desart.com.au/) and organic beef already in desert Australia (e.g. OBE Beef, http://www.obebeef.com.au/, see elsewhere in this conference), and again the issue arises as to whether the models are peculiar to the conditions of desert Australia. There is no doubt that the use of the internet and related technology is essential for facilitating the process (Yuendemu Art Centre sells directly into New York art dealers over the internet for example, http://www.warlu.com/), but what other public investments and new governance systems could help the success of these processes?

WHAT THIS MEANS FOR RANGELAND RESOURCES AND THEIR MANAGERS

Not all the issues raised above (and summarised in Table 1) are in the conventional ARS mould. However, we would argue that unless we all become a little more sophisticated in thinking about the wider concerns of regional economic development in inland Australia, then the natural resource management aspects that the ARS normally focuses on will be lost too. Clearly we emphasise the need to think about our natural resources slightly differently in terms of where the world around us is heading, and in terms of the market opportunities for the future. This has implications not only for the financial aspects of rangelands operations, but for the management and image that surrounds those operations. Conventional industries such as grazing and wild animal or plant harvesting enterprises need to consider how they will be positioned compared to non-rangelands industries in the future. And new bush products or service industries can seek to position themselves from the start with respect to ensuring their long-term competitive advantage.

The Desert Knowledge CRC is really only a small part of considering these issues since it remains that the ideas and innovations are mainly in the heads of all the desert people in the thousand kilometres or so surrounding us in Alice Springs. DK-CRC is seeking to address these issues through four research themes, as well as a series of cross-cutting activities:

a) Natural resource management for better livelihoods in desert environments
b) Technical services for improved community viability in Desert Australia
c) Governance, management and leadership leading to improved equity, opportunity and efficiency
d) Integrated systems for desert livelihoods - scaling up to regional economies.

Table 1. A summary of some desert knowledge-related opportunities and research implications raised.

Issue	Problem/opportunity	Research
Data bases for a coherent view of 'desert Australia'	• No coherent picture of desert regions except as hinterlands of each state's coastline	• Collection, collation and presentation across state boundaries
Variability, unpredictability, feedback and community learning	• Physical, social, institutional market and policy environment variable and distantly controlled, hence (seemingly) unpredictable • Peculiarly difficult to get experiential/ adaptive management feedback	• Focus on understanding (if not predicting) all aspects of variability (rather than averages) • Develop new ways of linking science and local knowledge systems to speed up local learning
Small communities, governance structures and statistics	• Individual events/people have disproportionate impact (+ and -)	• Understand the critical effects of small size and how to manage/benefit from them • Understanding the minimum community size for maintaining different functions
Critical mass and demand-driven services	• Obtaining local accountability yet building viable-sized services	• Developing institutional structures attaining the best balance between demand accountability and scale of service delivery
Agglomeration, social norms and linking to the rest of the world	• Conflicts between agglomerative forces and regionalisation ideology • Lack of recognition and data about structural social and economic constraints	• Better understanding of contribution of different activities to economic and social multipliers, and 'capital flight' • Analysis of social norms and conflicts between small and large communities
Differentiating our product and a "post-	• Not going to beat the world at their game	• Create new livelihood opportunities based on "non-market" values, possibly in conjunction with

productivist paradigm"	• Genuine competitive advantage in desert culture and environment – space, natural state, indigenous and outback culture, etc	conventional production values • Understand how to value, sustain and market our competitive advantage
Business networks and creating livelihoods	• Low critical mass • May need new models for business networks and market supply chains to function in remote areas, and permit appropriate benefit sharing	• Develop effective models for business networks, and supporting public investment • Identify and develop strategies to deliver desert-branded products to high-value, niche markets

In its first year of operations DK-CRC has sought to get a series of smallish, 1-2 year projects on the ground in these areas; these are now operating, and building a further set of data through case studies, pilots and community consultation on which to base the subsequent five years investment. During the remainder of 2004 we now aim to take on a great deal of consultation with the community and other stakeholders, in order to focus our on-going investment into fewer, larger efforts which have the potential to make the difference on key issues of importance to the future of desert Australia. This will mean dropping some research areas in favour of others. We welcome your input now or over the next few months as to what you perceive to be the critical areas for our research investment.

ACKNOWLEDGMENTS

Our thanks to the DK-CRC Board and Management Team (particularly our reviewers Bruce Walker and Murray McGregor), and many people engaged in Desert Knowledge Australia, who helped to develop these ideas, although the expression of them here is our responsibility alone. This is a publication of the Desert Knowledge CRC, supported by funding from the Australian Government's Cooperative Research Centre Programme.

REFERENCES

Holmes, J.H. (1997). Diversity and change in Australia's rangeland regions: translating resource values into regional benefits. *The Rangeland Journal* 19: 3–25.

Holmes, J. (2002). Diversity and change in Australia's rangelands: a post-productivist transition with a difference. *Transactions of the Institute of British Geographers* 27: 362–384.

Lynam, T. and Stafford Smith, M. (2003). Monitoring in a complex world – seeking slow variables, a scaled focus, and speedier learning. *Proc. VII International Rangelands Congress*, Durban Jul 2003. 9pp on CD-ROM.

Stafford Smith, M., Walker, D., Maru, Y., Stoeckl, N., Herr, A., Breen, J. and Greiner, R. (2003). *Options for Understanding Regional Dynamics in Northern Australia.* Tropical Savannas CRC Project Report, July 2003, CSIRO, Alice Springs, 110 pp.

Taylor, J. (2003). Population futures in the Australian desert, 2001-2016. *Australian Geographer* 34: 355-370.

Taylor, J.A. (2002). Key personal attributes and areas of knowledge for future success in the rangelands. *Proc. 12th Biennial Conf. of Austr. Rangeland Soc.*, Sept 2002, Kalgoorlie, pp.74-78.

A REVIEW OF EIGHT MAJOR DEGRADATION EPISODES IN THE HISTORY OF AUSTRALIA'S RANGELANDS - CAN WE PREVENT THE NINTH?

G.M. McKeon [1], W.B. Hall [2], B.K. Henry [1], S. Power [3], G.S. Stone [1], J.I. Syktus [1] and I. Watson [4]
in collaboration with K.A. Day [1] and J.O. Carter [1]

[1] NRM&E, 80 Meiers Road, Indooroopilly, Qld 4068[1]
[2] Meat and Livestock Australia, PO Box 3514, South Brisbane, Qld 4101
[3] Bureau of Meteorology Research Centre, GPO Box 1289K, Melbourne, VIC 3001
[4] Department of Agriculture Western Australia and Centre for Management of Arid Environments, PO Box 483, Northam, WA 6401

ABSTRACT

The paper describes lessons learnt from historical degradation episodes in Australia's rangelands. We have recently reviewed eight well-documented episodes and the processes that led to degradation and partial recovery. The dominant features of the degradation episodes were: a) an over-expectation of carrying capacity which damaged the rangeland resource during periods of favourable rainfall and intermittent drought; and b) multi-year sequences of severe and extended drought which revealed and further amplified degradation. We discuss what information sources are required by graziers, their advisers and governments to prevent the recurrence of these historical episodes. A major deficiency is the inability to predict severe and multi-year drought periods, especially droughts not associated with El Niño

INTRODUCTION

During the 150 years that Australia's rangelands have been used for grazing there have been many episodes of resource degradation and partial recovery. In a recently completed report (McKeon *et al.* 2004) we reviewed eight of these episodes in detail. These episodes were well documented in government inquiries and reports, as well as by graziers and the media of the day. From this analysis, we discuss the commonalities and the information systems that are required to aid decision-making in grazing management. We focus on the dominant impact of climate variability, the need for better climate information, and the emerging understanding of the climate system. These episodes provide a challenge to governments, resource managers, graziers and their advisers to reduce the impact of further episodes of degradation.

EVIDENCE OF DEGRADATION

Since 1956, the rangelands of Australia have continued to carry 8-14 million cattle and 18-40 million sheep (National Land and Water Resources Audit 2001). There have been major improvements in water distribution, property infrastructure, livestock genetics and animal supplementation. These management improvements and climatic variability can mask the impact of land degradation on livestock production. Nevertheless, we found that associated with some episodes, there were examples of permanent losses in livestock carrying capacity: Gascoyne, Western Australia after the 1930s (Williams *et al.* 1980); Cobar/Byrock in western NSW after the 1950s (Anon 1969); and south-west Queensland after the 1960s (Warrego Graziers Association 1988). In other episodes there were also examples of irreversible resource damage from soil erosion (e.g. Beadle 1948, Rogers *et al.* 1999).

[1] The views expressed herein are those of the authors and do not represent a policy position of the Queensland Government or the Department of Natural Resources, Mines and Energy or any other agency.

The eight historical episodes identified are briefly described in Table 1.

Table 1. Regional degradation episodes in Australia's rangelands (from McKeon *et al.* 2004)

The extended drought period (EDP) associated with each degradation episode was calculated using rainfall aggregated to regions. For consistency, a standard 12–month period (1 April to 31 March) was used. The first year of the extended drought period was the first year in which rainfall was below 70% of the mean. The drought was considered broken when average to well-above-average rainfall occurred. For Episode 5 which involved woody weed infestation in the 1950s, the impact was not revealed until a later drought period in the 1960s.
Episode 1: 1890s in western NSW involving soil erosion, woody weed impact, rabbit plagues, substantial financial losses and financial hardship, and resulting in the Royal Commission of 1901. EDP: 1898/99 – 1902/03.
Episode 2: 1920/30s in SA and western NSW involving substantial loss of perennial vegetation and soil erosion, resulting in government legislation for regulation of carrying capacity. EDP: 1925/26 – 1929/30.
Episode 3: 1930s in Gascoyne region of WA involving substantial loss of perennial shrubs, soil erosion and animal losses documented in the Royal Commission of 1940 and subsequent inquiries. EDP: 1935/36 – 1940/41.
Episode 4: 1940s in western NSW involving substantial dust storms and animal losses graphically portrayed in Drysdale's paintings and Newman's newspaper reports, and supporting the need for government action. EDP: 1941/42 – 1944/45.
Episode 5: 1950s in western NSW involving large increases in woody weeds resulting in reduced carrying capacity and income in the 1960s. EDP: 1964/65 – 1967/68.
Episode 6: 1960s in central Australia involving wind and water erosion resulting in extensive surveys and reassessment of carrying capacity. EDP: 1958/59 – 1965/66.
Episode 7: 1960/70s in south-west Queensland involving soil erosion and woody weed infestation, resulting in the government-sponsored South-West Strategy supporting review of recommended carrying capacities and property amalgamation. EDP: 1964/65 – 1967/68.
Episode 8: 1980s in north-east Queensland involving soil erosion and loss of desirable perennial grasses, resulting in extensive government-sponsored surveys and dramatic grazier response. EDP: 1984/85 – 1987/88.

Evidence of episodic degradation

Whilst the above episodes have some notoriety, the extent to which degradation is a continuous rather than an episodic process is debatable. Watson *et al.* (2004) developed simulation models of dynamics of edible shrubs to study the interaction of climate and grazing management for two episodes (Gascoyne region, Western Australia in the 1930s, and North East Soil District, South Australia in the 1920/30s). Their simulation results showed that the loss of shrubs was continuous under constant heavy utilisation, but was more episodic at lighter stocking rates. These results and the analysis by other researchers (e.g. Williams *et al.* 1980) suggest that the severe and extended drought periods: a) revealed previous resource degradation; and b) further amplified erosion and loss of desirable perennial grasses and shrubs. Models such as those of Watson *et al.* (2004) provide an experimental system (albeit simulation-based) for the testing of different grazing management options and their interaction with climate variability, and the relative importance of episodic and continuous degradation processes. Further research is underway to develop models for each of the episodes described above.

COMMONALITY OF DEGRADATION EPISODES

No two droughts or two degradation episodes have been the same, but some commonalities emerged from the eight episodes. It is this repetition of factors, common to events in different places and at different times, that provides the potential for anticipating and preventing future damage. Common factors were:

- A general over-expectation of safe carrying capacities by managers, investors and governments.
- Numbers of stock and other herbivores (e.g. rabbits, kangaroos and goats), and in some cases woody weed seedlings, had increased in response to a period of mainly above-average rainfall that preceded the drought/degradation episode.
- Intermittent dry seasons (or years) resulted in heavy utilisation damaging desirable perennial species and ultimately the grazing land resource. This led to a rapid collapse in the capability of the land to carry animals at the onset of drought.
- Very high utilisation in the early years of drought through retaining stock caused further loss of perennial species, exacerbating the effects of drought in subsequent years.
- Rapid decline in, or generally low, commodity prices resulted in some managers retaining stock in the hope of better prices or through fear of the high cost of restocking.
- Continued retention of stock through a long drought period compounded damage to the resource and delayed recovery.
- Recovery was mainly dependent on subsequent sequences of favourable years, sometimes decades after the drought episode.

IMPORTANCE OF CLIMATE VARIABILITY

Climate variability has played a major role in driving this 'cycle' of degradation and partial recovery. We have reviewed the emerging understanding of the global climate system and the major sources of variability (McKeon *et al.* 2004). A recent analysis of global sea surface temperatures (SSTs) and atmospheric pressures (Allan 2000) has shown that variability occurs at different time scales, e.g. quasi-biennial (e.g. 2.5 years), inter-annual (e.g. 3-7 years), quasi-decadal (e.g. 11-13 years) and inter-decadal (e.g. 15-20 years). Other natural factors include solar variability, volcanic emissions and the chaotic nature of the climate system itself. Human-induced factors affecting the climate system include the increasing concentration of greenhouse gases, depletion of stratospheric ozone, increasing aerosols from industrial development, and land cover change from agricultural and urban development.

Recent research has shown that interactions of fluctuations in Pacific Ocean SSTs, at different time scales, have been associated with sequences of above- or below-average rainfall in Australia's rangelands, in particular in eastern Australia (McKeon *et al.* 2004). The El Niño-Southern Oscillation (ENSO) phenomenon is a well-publicised inter-annual fluctuation which changes the probability of droughts and floods from year to year (McBride and Nicholls 1983). Research (Power *et al.* 1999, Mantua and Hare 2002) has also identified inter-decadal fluctuations in Pacific Ocean SSTs, and various indices have been proposed. Historical time series are available for the Inter-decadal Pacific Oscillation (IPO, Power *et al.* 1999) and Pacific Decadal Oscillation (PDO, Mantua and Hare 2002).

The possible interaction of ENSO and the IPO/PDO adds to the complexity of understanding rainfall variability. A major finding in our report was that in eastern Australia, the impact of La Niña years has been greatly enhanced when the inter-decadal component of the Pacific Ocean was in a mode characterised by a very large wedge-shaped body of cold water dominating not only the equatorial region of the eastern Pacific, but also extending into the extra-tropical regions of the northern and southern hemispheres (IPO/PDO *cool* phase). The above-average rainfall periods in eastern Australia coincided with the *cool* phase of the IPO/PDO (early 1890s, 1916-18, early 1920s, mid 1950s, early 1970s, and perhaps late 1990s). The effect on rainfall of the interaction of El Niño and phases of the

IPO/PDO has varied greatly with location in eastern Australia (Henry *et al.* 2004, this volume).

Indices of the IPO/PDO were *warm* for most of the period from 1925 to 1946 and *cool* for most of the period from 1947 to 1976, and hence provide supporting evidence for the shift in climate regimes that has been identified as a contributor to the recovery of vegetation, for example, in western New South Wales (Condon 2002) and South Australia. In eastern Australia, the major periods of woody weed establishment, increasing animal numbers, and also potential resource recovery have been associated with the *cool* phase of the IPO/PDO when sequences of above-average rainfall years have occurred (early 1890s, mid 1950s, early 1970s and perhaps late 1990s). Most of the degradation episodes occurred when the IPO/PDO indices were *warm* or neutral, and the chance of 'drought-breaking' (above-average) rainfall was not as high as in the *cool* phase of the IPO/PDO.

Frustratingly for scientists and graziers alike, the existence of mechanisms and predictability of inter-decadal fluctuations such as the IPO/PDO are still the subject of debate, and the capability to predict 'regime changes' is not yet available (Mantua and Hare 2002). Nevertheless, it is clear that the impact of ENSO on Australian rainfall has waxed and waned (Power *et al.* 1999). What is unclear is the extent to which the 'waxing and waning' can be predicted. There is hope that some aspects of this interaction of oscillations at different time scales can at least be represented in climate forecasting or risk assessment systems a year at a time (e.g. Day *et al.* 2000, White *et al.* 2003), though more research is needed.

Application of climate information

Current operational seasonal climate forecast systems (SCFs) have concentrated on 3-monthly seasonal outlooks using ENSO and in some cases Indian Ocean SSTs (e.g. Drosdowsky and Chambers 1998, Alemseged *et al.* this volume). A limitation of ENSO-based forecasts is that only a small (≈ 25%) proportion of the years in the extended drought periods were associated with El Niño. Hence the prediction of severe regional drought in non-El Niño years remains as a major challenge.

The perceived importance of annual rainfall variability in management has led to the proposal/development of various experimental systems with longer lead times which are currently being tested and/or documented (Day *et al.* 2000, Henry *et al.* this volume). However, many factors are contributing to difficulties of speeding adoption (Paull, Leith this volume): the plethora of systems, the danger of false skill, the long time required to gain confidence in new statistical systems, and the probabilistic nature of climate forecasts. Systems based on historical rainfall also have to address the issue of how to include climate change impacts from the various human-induced forcings.

An alternative is the use of forecasts derived from Global Climate Models (GCMs). GCMs are a numerical representation of the global climate system including ocean and atmospheric circulation, and are beginning to include both natural and human-induced climate forcings. Trial operational SCFs have been produced since 1997 (Syktus *et al.* 2003). However, as with statistical systems, widespread adoption of such forecasts will require further model development, and then time for public confidence to be gained. The Bureau of Meteorology has recently been providing routine forecasts with the Predictive Ocean Atmosphere Model for Australia (POAMA) based on a coupled atmosphere-ocean GCM. http://www.bom/gov.au/bmrc/ocean/JAFOOS/POAMA/

Using GCMs, J. Syktus (unpublished data) has carried out several simulation experiments to investigate possible causes of 'extreme' sequences of droughts (e.g. 1960s central Australia, 1990s coastal Queensland) and wet years (rangelands of Western Australia in the 1990s). Although the results are preliminary, we believe they have important implications for future research. The GCM experiments suggest that the observed decline in coastal rainfall, especially during the recent La Niña period was best simulated by the inclusion of human-induced forcings. In particular, the inclusion of the depletion of stratospheric ozone over the last 30 years was found to be important to represent the changes in rainfall across Australia and trends in atmospheric pressure in the Southern Hemisphere. A preliminary experiment was also carried out to investigate the causes of the severe drought in the late 1950s/early 1960s across central Australia. GCM simulations forced with observed SSTs did not represent the drought conditions during this period. However, when continental soil moisture was set to low values in 1957 (as suggested by soil moisture simulations from the AussieGRASS model, Carter *et al.* this volume) then rainfall deficits were simulated to occur in central Australia for up to three years (i.e. 1958/59 to 1960/61). The preliminary results support the need for further research using a GCM-based approach to understand and hopefully predict the extended drought periods described above.

A SYSTEMS APPROACH TO PREVENT DEGRADATION

The review of the historical degradation episodes has identified some major information gaps that need to be addressed to lead to more informed decisions in grazing management and support effective rangeland management.

Monitoring of resource condition

The episodes described above caught resource managers and governments unaware, with the media in some cases being the first to identify that 'all was not well'. By the time that degradation became apparent (soil erosion and dust storms, loss of carrying capacity in drought, woody weed infestation, economic hardship) it was too late to take action to protect the rangeland resource. However, there have been some improvements. Since the 1980s various resource monitoring systems have been in place in State agencies (e.g. Watson 1998) to measure long-term changes. Developments have also been occurring in the use of satellite data to measure (in near real-time) changes in ground cover, tree density and pasture biomass. However, the major drivers of the degradation, namely livestock and other herbivore numbers, are proving more difficult to monitor or interpret in some States.

Lack of understanding of climate variability and impact on safe carrying capacity

The over-expectation of carrying capacity was supported by periods of above-average rainfall. With the benefit of hindsight, and a hundred years of climate data, the rangeland community now has a better appreciation of the long-term climate that underpins successful grazier experience and the calculation of 'safe' carrying capacities (Johnston *et al.* 2000, Quirk and O'Reagain 2003). However, to some extent the community is now back in a state of 'climate ignorance' similar to that of our predecessors. Climate change scenarios (Pittock 2003) suggest that the impact of human-induced factors on regional rainfall may be as large as natural climate variability (calculated on a 30 year timescale). Prediction systems addressing natural decadal and longer timescale signals are also yet to be proven. Thus a major priority is the development of plausible climate scenarios for (at least) the next 30 years, for use in estimating safe carrying capacities, and anticipating the likely climate variations that have caused the devastating impact reported in previous degradation episodes.

Prediction of severe and multi-year drought

Each episode included periods of two or more years of extreme drought (e.g. annual rainfall less than 70% of mean). To our knowledge current SCFs are yet to be evaluated in terms of forecasts of extreme drought. Operational SCFs concentrate on the probability of above or below median rainfall or in some cases the chance of Tercile 1 rainfall. Preliminary studies with GCMs using ensembles of simulations to calculate probabilities are now addressing issues such as chaos, biospheric feedback and the role of human-induced forcings to estimate changing risks of extreme rainfall occurrence.

Drought and degradation alerts

Individual graziers monitor pasture and animal condition and combine this knowledge with hard-won experience and rainfall expectations to anticipate the devastating impacts of drought (Purvis 1986, Landsberg *et al.* 1998, Stone 2004). More formal approaches have also been suggested (Bartle 2003, Quirk and O'Reagain 2003). The approach in the AussieGRASS model developed by state agencies (Day *et al.* 2003, Carter *et al.* this volume) has been to formally calculate attributes of the grazing system such as soil moisture, pasture biomass, and grass basal cover. This approach has formed the basis for: a) identifying periods of feed deficit; b) ranking current conditions relative to simulations of historical pasture growth; and c) supporting assessment of drought for Exceptional Circumstances application. However, the conversion of drought alert systems into a degradation alert depends, to some extent, on estimates of livestock and other herbivore numbers as well as improved skill and lead-time in climate forecasting.

Understanding the major cause of resource resilience

Various studies have documented partial recovery from degradation. An important feature of this recovery has been sequences of above-average rainfall years, for example, in western New South Wales following the wet periods of the 1950s and 1970s (Condon 2002). In eastern Australia, these years have been associated with La Niña years and/or the *cool* phase of the IPO/PDO. Thus, to some extent the perceived resilience of the land appears to have resulted from the decadal/inter-decadal variation in the Pacific Ocean's SSTs. Given the apparent importance of these 'La Niña-like' periods to the recovery and resilience of rangeland ecosystems, evaluation of the likely impact of global warming on their future occurrence is a major criteria in terms of assessing climate change impacts. This is particularly important if current projections of the development an 'El Niño-like' mean state in the equatorial Pacific Ocean occur (Cai and Whetton 2000).

The role of year-by-year climate risk assessment

An important finding from surveys and observations conducted during the last two degradation episodes was that graziers who acted rapidly to reduce numbers came out of the drought episodes in a better financial position with higher livestock reproductive rates and better resource condition (i.e. surface cover) than those graziers who 'hung on'. This was supported in the recent (current) drought by anecdotal examples (Wahlquist 2003). Thus, a major role for SCFs is to provide the necessary climate risk assessment that would allow discrimination between a relatively short 'dry spell' and the conditions leading to a severe and prolonged drought period.

CURRENT RISK OF A DEGRADATION EPISODE

During the late 1990s, sequences of years with above-average rainfall have supported the increase in livestock and other herbivore numbers, increasing from the drought period of the early 1990s. For example, in Queensland, G.S. Stone (unpublished data) estimated that cattle and sheep numbers (expressed as adult beef equivalents) had increased from 10.3 million at the end of a drought period in 1995 to 11.7 million in 2000. In 2001, Queensland macropod numbers were estimated (A. Pople *pers. comm.*) to have increased to 24 million (≈ 1.5 million beef equivalents). Similarly, in the Gascoyne region of Western Australia, livestock equivalents in 2001 were over one and a half times as high as at the end of the drought in 1980, down somewhat after reaching a peak of almost double in the late 1990s.

Drier conditions commenced in several rangeland regions of Australia in 2001 with a widespread drought in 2002. The potential for high grazing pressure, resulting from livestock and other herbivores, was a major concern because of the possible increased risk of degradation. Prices for both sheep and cattle remained reasonable during this period, although volatile, allowing graziers to reduce numbers in many cases. For Queensland, we have monitored trends in resource condition, animal (livestock and macropods) numbers (where available), prices and climate indicators (ENSO, PDO). However, developing a capability to provide a comprehensive assessment at a regional scale remains a major challenge. We are using the report of the above episodes to raise awareness.

CONCLUSION

In summary, we suggest that information systems are evolving to support better management decision in the rangelands. Prevention of future degradation episodes will require: a) recognition of the impact of historical climate variability and over-expectation of carrying capacity (McKeon *et al.* 2004); b) monitoring of attributes of resource condition (cover, biomass, woody vegetation, fire regimes); c) near real-time assessment of pasture production and grazing pressure (e.g. Carter *et al.* this volume) for livestock and other herbivores; d) use of climate risk assessment tools to project consequences of maintaining current grazing pressure; e) extension and information delivery through industry-supported programs (e.g. MLA's EDGE*network* Grazing Land Management course, Quirk and O'Reagain 2003); and f) facilitation and recognition of appropriate action by graziers to reduce degradation risk.

ACKNOWLEDGEMENTS

Preparation and publication of the report have been supported by the Queensland Department of Natural Resources, Mines and Energy through Natural Resource Sciences; the Australian Government through the Australian Greenhouse office; and Agriculture, Fisheries and Forestry-Australia and Australia's Rural Research and Development Corporations under the Climate Variability in Agriculture Program.

REFERENCES

Alemseged, Y., Hacker, R.B., Hayman, P.T., Carberry, P.M. and Henry, B.K. (this volume). Improved seasonal forecasts for wool producers in western NSW.

Allan, R.J. (2000). ENSO and climatic variability in the last 150 years. *In* El Niño and the Southern Oscillation: Multiscale Variability, Global and Regional Impacts (Eds H.F. Diaz and V. Markgraf). pp. 3–55. Cambridge University Press, Cambridge.

Anon. (1969). Report of the interdepartmental committee on scrub and timber regrowth in the Cobar–Byrock district and other areas of the Western Division of New South Wales. Government Printer, Sydney.

Bartle, R. (2003). Measuring stocking rate and carrying capacity relative to rainfall. *Australian Farm Journal* (February 2003) 12: 28–29.

Beadle, N.C.W. (1948). The Vegetation and Pastures of Western New South Wales with Special Reference to Soil Erosion. Government Printer, Sydney.

Cai, W. and Whetton, P.H. (2000). Evidence for a time–varying pattern of greenhouse warming in the Pacific Ocean. *Geophysical Research Letters* 27: 2577–80.

Carter, J., Bruget, D., Day, K., Hassett, R., Henry, B., Cowley, R., Heidenreich, S., Leys, J., Maconochie, J., McKeon, G., Peacock, A. and Watson, I. (this volume). AussieGRASS: Australian Grassland and Rangeland Assessment by Spatial Simulation: New developments and applications.

Condon, R.W. (2002). *Out of the West: Historical Perspectives on the Western Division of New South Wales*. Lower Murray Darling and Western Catchment Management Committees, Rangeland Management Action Plan, 444pp.

Day, K.A., Ahrens, D.G., Peacock, A., Rickert, K.G. and McKeon, G.M. (2000). Climate tools for northern grassy landscapes. *Proceedings of the Northern Grassy Landscapes Conference, Katherine.* 29–31 August 2000. pp. 93–97. Cooperative Research Centre for the Sustainable Development of Tropical Savannas.

Day, K.A., Ahrens, D.G. and McKeon, G.M. (2003). Simulating historical droughts: some lessons for drought policy. *Proceedings of the National Drought Forum: Science for Drought* 15-16 April 2003. Brisbane, Queensland, pp. 141-151.

Drosdowsky, W. and Chambers, L. (1998). Near global sea surface temperature anomalies as predictors of Australian seasonal rainfall. *BMRC Research Report No. 65*. Bureau of Meteorology, Australia. 39pp.

Henry, B., Bruget, D., Carter, J., Cobon, D., Flood, N., Hacker, R., McKeon, G., Peacock, A., Truscott, M. and Watson, I. (this volume). Improved climate forecasts for Australia's wool producers.

Johnston, P.W., McKeon, G.M., Buxton, R., Cobon, D.H., Day, K.A., Hall, W.B. and Scanlan, J.C. (2000). Managing climatic variability in Queensland's grazing lands – new approaches. *In* Applications of seasonal climate forecasting in agricultural and natural ecosystems – the Australian experience. (Eds G. Hammer, N. Nicholls and C. Mitchell.) pp. 197–226. Kluwer Academic Press, Netherlands.

Landsberg, R.G., Ash, A.J., Shepherd, R.K. and McKeon, G.M. (1998). Learning from history to survive in the future: Management evolution on Trafalgar Station, north–east Queensland. *Rangeland Journal* 20: 104–18.

Leith, P. (this volume). Climatic place: A socio-cultural geography of climate risk management.

Mantua, N.J. and Hare, S.R. (2002). The Pacific Decadal Oscillation. *Journal of Oceanography* 58: 35–44.

McBride, J.L. and Nicholls, N. (1983). Seasonal relationships between Australian rainfall and the Southern Oscillation. *Monthly Weather Review* 111: 1998–2004.

McKeon, G.M., Hall, W.B., Henry, B.K., Stone, G.S. and Watson, I.W. (2004). Pasture degradation and recovery in Australia's rangelands: Learning from History. Queensland Department of Natural Resources, Mines and Energy.

National Land and Water Resources Audit (NLWRA) (2001). Rangelands – Tracking Changes – Australian Collaborative Rangeland Information System. National Land and Water Resources Audit, Canberra.

Paull, C.J. (this volume). Processes for using climate-risk-management information in rangeland enterprises.

Pittock, A.B. (2003). Climate change: An Australian Guide to the Science and Potential Impacts. Australian Greenhouse Office.

Power, S., Casey, T., Folland, C., Colman, A. and Mehta, V. (1999). Inter–decadal modulation of the impact of ENSO on Australia. *Climate Dynamics* 15: 319–24.

Purvis, J.R. (1986). Nurture the land: My philosophies of pastoral management in central Australia. *Australian Rangeland Journal* 8: 110–17.

Quirk, M. and O'Reagain, P. (2003). Managing grazing lands in a variable climate. *In* National Drought Forum 2003: Science for Drought. Queensland Department of Primary Industries. pp. 101-105.

Rogers, L.G., Cannon, M.G. and Barry, E.V. (1999). Land resources of the Dalrymple Shire. Vols. I & II. Land Resources Bulletin DNRQ980090. Queensland Department of Natural Resources. QDNR and CSIRO, Brisbane.

Stone, G.S. (2004). Analysis of grazing pressure from the long-term livestock records of two western Queensland pastoral properties. *In* G.M. McKeon, W.B. Hall, B.K. Henry, G.S. Stone and I.W. Watson, eds. Pasture degradation and recovery in Australia's rangelands: Learning from History. Queensland Department of Natural Resources, Mines and Energy. pp. 191-235.

Syktus, J, McKeon, G., Flood, N., Smith, I. and Goddard, L. (2003). Evaluation of a dynamical seasonal climate forecast system for Queensland. *In* National Drought Forum 2003: Science for Drought. Queensland Department of Primary Industries. pp. 160-171.

Wahlquist, A. (2003). Media representations and public perceptions of drought. *In* Beyond Drought: People, Policy and Perspectives. (Eds L.C. Botterill and M. Fisher) pp. 67-86. CSIRO Publishing, Collingwood, Victoria.

Warrego Graziers Association (1988). Submission to the United Graziers Association on the degradation of south–west Queensland. Charleville, Queensland, Australia. 46pp.

Watson, I.W. (1998). Monitoring Western Australian shrublands; what are the expectations of change? *Range Management Newsletter* 98 (2): 1–5.

Watson, I.W., McKeon, G.M. and Wilcox, D.G. (2004). Modelling climate and management effects on shrub populations in the Gascoyne area of Western Australia and the North East District of South Australia. *In* G.M. McKeon, W.B. Hall, B.K. Henry, G.S. Stone and I.W. Watson, eds. Pasture degradation and recovery in Australia's rangelands: Learning from History. Queensland Department of Natural Resources, Mines and Energy. pp. 173-190.

White, W.B., McKeon, G.M. and Syktus, J.I. (2003). Australian Drought: The Interference of Multi–Spectral Global Standing Modes and Travelling Waves. *International Journal of Climatology* 23: 631–62.

Williams, O.B., Suijdendorp, H. and Wilcox, D.G. (1980). The Gascoyne Basin. *In* Desertification, associated case studies prepared for the United Nations Conference on Desertification (Eds M.R. Biswas and A.K. Biswas) pp. 3–106 Pergamon Press, Oxford.

AUSTRALIAN RANGELANDS: MANAGING THE RISKS OF CLIMATE CHANGE

S.M. Howden [1], *S. Crimp* [2] *and A.J. Ash* [3]

[1] CSIRO Sustainable Ecosystems, GPO Box 284, Canberra, ACT 2601
[2] Queensland Natural Resources, Mines and Energy, Meiers Rd, Indooroopilly, Qld 4068
[3] CSIRO Sustainable Ecosystems, 306 Carmody Road, St Lucia, Qld 4067

ABSTRACT

The IPCC Third Assessment Report confirms that the evidence for global climate change is now stronger than ever. While efforts to minimise climate change are critical, some degree of change is already inevitable. The key questions for rangelands are no longer whether climate change will occur, but how to adapt to it so as to mitigate its negative impacts and take advantage of any positive impacts. This paper briefly outlines the likely future changes, the likely impacts of those changes for Australian rangelands and the analysis of strategies at the farm scale and at the national scale which could help to make rangelands and rangeland livelihoods sustainable even in the presence of climate change.

INTRODUCTION

Human activities appear to be affecting the global climate. Global mean temperatures have risen approximately 0.7°C since the mid 1800s and changes in rainfall patterns, sea levels, rates of glacial retreat and biological responses have also been detected which are consistent with expectations of 'greenhouse' climate change. The most recent report of the Intergovernmental Panel on Climate Change (IPCC 2001) concluded that there is now stronger evidence of a human influence on global climate and that these trends will continue for the foreseeable future due to continued emissions of carbon dioxide (CO_2) and other greenhouse gases from fossil fuels and other sources. The most recent predictions are for an increase in global average temperatures of 1.4-5.8°C by the end of the present century. Intuitively, it is hard to conceive that such changes will not have implications for Australia's rangelands. Furthermore, temperature records such as those from the Vostok ice core (Petit *et al.* 2000) demonstrate that such high global temperatures have not been experienced before by the human species – we have no precedent for managing them. In addition to these projected temperature increases there will be increases in atmospheric carbon dioxide (CO_2), changes in mean rainfall with the prospect of substantial rainfall declines (up to 40%) across the southern half of Australia in particular, increases in rainfall intensity and the possibility of entering a more El-Niño-like mean climate condition. Consequently, the IPCC Third Assessment Report (IPCC 2001) concludes that rangelands in Australia have significant vulnerability to the changes projected over the next decades to 100 years, adding to the existing, substantial pressures on these regions.

HOW WILL GLOBAL CHANGE AFFECT RANGELANDS?

The higher atmospheric CO_2 concentrations that are inevitable in the future (ranging from 500 ppm to 900 ppm by 2100: IPCC 2001) are highly likely to increase the aboveground plant productivity in rangelands. Experiments show that increases of atmospheric CO_2 concentrations to 700 ppm significantly increase productivity of plants by 10-15% in mesic environments and 20 to 40% in water-limited situations (Wand *et al.* 1999) with doubling of above-ground production in dry seasons (Stokes *et al.* 2003). The main mechanism is an increase in water use efficiency arising from reduced stomatal apertures under elevated CO_2. There can also be some photosynthetic enhancement. The stimulatory effect on production levels off as the CO_2 concentration rises. The capacity to express this CO_2 'fertilisation' is affected by other factors such as species composition, temperature, soil nutrient availability and soil moisture leading to variable growth response. However, any increases in production may be offset by projected reductions in rainfall and increases in evaporation (Hall *et al.*

1998). For those rangelands where a large net drying is predicted (e.g. southern Australia), the effects may more than cancel each other out, resulting in reduced primary production.

Increased temperatures may increase pasture production in areas where low temperature limits the growing season, particularly in areas where C_4 grasses predominate, where soil nutrition is adequate and in years where soil moisture is not limiting (Hall *et al.* 1998). Conversely, in more southern regions where winter-growing pastures are more common, higher temperatures may reduce the length of the growing season, limiting forage accumulation and livestock performance.

The suggested increased competitive capacity of woody plants over grasses with higher CO_2 levels, based on differences in their photosynthetic mechanisms, remains speculative (Archer *et al.* 1995). More recent modelling work (Bond *et al.* 2003) suggests that the increase in CO_2 experienced in the last 120 years is large enough to explain increasing woodiness in savannas because regrowth of trees between fire events is fast enough that many can escape the damaging effects of the next fire. If, however, burning frequency is adjusted to higher grass biomass with increased CO_2 concentrations in the future, there may be increased opportunities to control woody plant establishment (Howden *et al.* 2001) provided that rainfall doesn't decrease too markedly.

Experiments have generally shown that elevated concentrations of CO_2 significantly decrease leaf nitrogen content (but not necessarily total plant nitrogen), increase easily-digested non-structural carbohydrates such as sugars and starch, but cause little change in digestibility in those species studied so far (Lilley *et al.* 2001). The implications of these changes differ between production systems. In production systems with high nitrogen forage (e.g. temperate pastures) the effects of CO_2 are likely to increase energy availability, increasing both nitrogen processing in the rumen and livestock productivity. In contrast, in chronically nitrogen deficient situation (many rangelands for part of the year), the effect of CO_2-induced nitrogen dilution may be to exacerbate the existing problems of low livestock productivity. This effect may be compounded if there is concurrent warming as warmer conditions tend to decrease digestibility and nitrogen content in tropical species (Wilson 1982). Such warming trends will also substantially increase the frequency of heat stress days, particularly in tropical climates, reducing productivity, decreasing reproductive rates, increasing mortality and increasing concerns about animal welfare in intensive livestock handling activities such as live sheep exports (Howden *et al.* 1999). The correlation of heat stress tolerance and lower productivity breed characteristics means that the search for effective adaptation to more heat stress will be challenging. In contrast, rising temperatures, in particular minimum temperatures, may result in a reduction in the frequency and severity of cold-stress events, such as conditions which foster high lamb mortality, although research to further understand this interaction has been limited.

Reductions in rainfall and increases in evaporation rates may combine to make surface water more scarce in many rangelands. Even where there is water available, higher temperatures are likely to increase water consumption by livestock, limiting the distance foraging takes place from watering points with consequent higher risks for sustainable management and reduced production.

During periods of decreased rainfall and plant-cover, rangelands become highly susceptible to soil erosion. This process serves to reduce pasture productivity through loss of valuable soil nutrients (Hall *et al.* 1998). In areas where climate models simulate increases in extreme daily rainfall, in conjunction with reductions in annual rainfall amounts, soil erosion may become an increasingly important management consideration.

The incidence and distribution of pests and diseases is likely to alter with climate change. Examples include the possible southward expansion of the insect vector of blue-tongue disease in Australia (*Culicoides wadia),* of bush ticks and of tropical parasites (Sutherst 1990, 2001).

There is a general expectation that there will be a loss of plant community integrity with climate change. This alteration in community composition may arise via expected changes in range of C_3 and C_4 species under global change, substantial differences in CO_2 responses by different species and change in the factors such as fire, which influence species survival and competition. In addition, there are predictions of accelerating invasion by 'alien' plants. For example, Prickly Acacia (*Acacia nilotica*) may expand southwards and into more arid lands than it currently occupies (Kriticos *et al.* 2003). The consequences for animal production from rangelands are generally negative, since highly palatable species are typically not among the successful invaders. The consequences for the conservation of rangeland biodiversity could be dire.

HOW CAN RANGE MANAGERS ADAPT TO CLIMATE CHANGES?

Even under the most optimistic scenarios of future greenhouse gas emissions reductions, the need for adaptation is now a given, since some processes of climate change are already underway, and the atmospheric concentrations of greenhouse gases will continue to rise even if emissions are substantially reduced. It is not a foregone conclusion that a warmer world will overall be worse for Australian rangelands, but in the process of transition, which is likely to last for centuries, significant changes in location and practice may be required. Gradual adaptations, such as a shift to breeds with greater temperature tolerance, and shifts in the mix of land use practices in given regions, are likely to take place with little policy intervention beyond support for research and extension, since they are not qualitatively different from the adaptations routinely faced by pastoralists in tracking market and technology trends and decadal shifts in climate. With increased rainfall variability and potentially more persistent El Niño like conditions under climate change, it would seem appropriate that rangeland managers be more proactive in managing current climate variability through tracking forage supply and forage budgeting or increased use of seasonal climate forecasts. However, more substantial and rapid climate changes may require more active policies so as to limit negative impacts. It is important to ensure that policy goals are periodically reviewed and re-set appropriately, for example, varying policies from industry support to industry restructuring (Scholes and Howden 2003).

The direct impacts of climate change on Australian agriculture will be the result of the combined effect of CO_2 increases, temperature increases, changes in evaporation and changes in the mean, variability and intensity of rainfall. It will be the integrated impacts of these changes that we will need to adapt to – either to counter negative impacts or take advantage of positive ones. These adaptations can be thought of as being applicable at different spatial scales, for example, national policy level or farm-level. Some of these adaptations are outlined below.

Table 1. National-scale climate change issues and suggested policy activities to enhance adaptation (Howden *et al.* 2003).

Issue	Action
Policy	Establish linkages to existing initiatives to enhance resilience
Managing transitions	Provide support during transitions to new systems
Communication	Develop industry-specific and region-specific information
R&D and training	Use a participatory approach to improve self-reliance and provide the knowledge base for adaptation
Model development and application	Develop systems modelling to integrate and extrapolate anticipated changes
Climate data and monitoring	Maintain data collection to link into ongoing evaluation and adaptation
Seasonal climate forecasting	Communicate to allow incremental adaptation when linked to other information
Breeding and selection	Support programs and ensure access to global gene pools
Pests, diseases and weeds	Enhance quarantine measures, sentinel monitoring and management
Water	Establish trading systems that allow for climate variability and climate change, improve distribution systems, develop water management tools and technologies
Landuse change and diversification	Undertake risk assessments and support rational changes

National and regional adaptation - developing more resilient systems

The high levels of uncertainty in future climate changes suggest that rather than try to manage for a particular climate regime, we need more resilient rangeland systems (including socio-economic and cultural/institutional structures) to more flexibly and rapidly cope with a broad range of possible changes, for example changes in global markets or a major new pest or weed may have far more impact on the rangelands than climate change. There is a substantial body of both theory and practice on resilient systems (e.g. Gunderson *et al.* 1995). However, enhanced resilience usually comes with various types of costs or overheads such as building in redundancy, increasing enterprise diversity and moving away from systems that maximise efficiency of production at the cost of broader sustainability goals. One approach to developing more resilient rangeland regions is to develop an adaptive management strategy where policy is structured as a series of experiments which have formal learning and review processes. However, this could provide a serious challenge to some rangeland institutions which are based on precedent (and hence only look 'backwards' not 'forward'), have a short-term focus only and which are risk averse (see Abel *et al.* 2002). Nevertheless, there is a large range of policy activities which could be undertaken which will enhance the capacity of Australian agriculture to deal with a changing climate (Table 1).

The options for biodiversity management in the rangelands of the future are currently mostly speculative. The optimal distribution of protected areas may have to be re-thought, with greater emphasis on their resilience in the face of climate change and exotic invasions, and greater emphasis on maintaining the existing conservation estate, particularly in 'refuge' areas. Existing conservation management activities may need reinforcement, with more consideration taken of climate vulnerability and increasing attention will be needed to manage for conservation on the 'matrix lands' between protected areas (van Jaarsveld *et al.* 2003). Even if a landscape can be designed to be 'permeable' to migrating species, the rate of climate change is likely to exceed the dispersal rate of all but the most mobile organisms (e.g. leading to the likelihood of more weeds). Some form of assisted dispersal is likely to be necessary, but this raises various issues of ethics, management and cost-effectiveness. *Ex situ* conservation is a strategy of last resort, but may be a necessary insurance policy for a few iconic species (Dunlop and Howden 2003).

Farm level adaptation – managing climate change risks

In addition to policy settings that could facilitate adaptation, there are many farm-level adaptations that could be undertaken (Table 2). Again, these are not markedly different from those strategies used to manage climate variability and fluctuating markets, although the emphasis can differ. As first noted by McKeon *et al.* (1993), one strategy to incrementally adapt to climate changes may be achieved by altering management according to seasonal climate forecasts.

In order for adaptation to climate change to be successful, it will need to incorporate both pre-emptive and reactive adaptive strategies and will need to occur in conjunction with already changing social, economic and institutional pressures. With this in mind, adaptation measures aimed at mitigating the negative impacts of climate change will have to reflect and enhance current 'best-practices' designed to cope with adverse conditions such as drought. Whilst a range of technological and managerial options may exist as indicated in Table 2, the adoption of these new practices will require: 1) confidence that climate changes several years or decades into the future can be effectively predicted against a naturally high year to year variability in rainfall that characterises these systems, 2) the motivation to change to avoid risks or to use opportunities, 3) development of new technologies and demonstration of their benefits, 4) protection against establishment failure of new practices during less favourable climate periods; and 5) alteration of transport and market infrastructure to support altered production (McKeon *et al.* 1993). Adaptation strategies that incorporate the above considerations are more likely to be of value, as they will be more readily incorporated into existing on-farm management strategies.

One pathway forward is to develop knowledge via participatory processes at both farm and institutional levels (e.g. Abel *et al.* 2002). Participatory approaches are useful as they deal directly with the key concerns of the owners of the problems, draw on their valuable expertise and also contribute to enhanced knowledge in the rangeland community. In terms of assessing the future productivity and sustainability of rangelands as part of such participatory research processes, rainfall and its variability are the most important climate variables. Reduction in the uncertainty surrounding their future state is a high priority but there will remain high uncertainty for rainfall projections because of the irreducibly chaotic nature of some of the processes. Hence, a probabilistic approach based on risk assessment is likely to be necessary for the foreseeable future. For policy analyses, such risk-based approaches need to be extended to include key driving factors such as population growth and projected increasing demand for meat, milk and other livestock products.

Table 2. Farm level adaptations to manage risks of climate change (from Howden *et al.* 2003).

Managing climate change risks –pasture productivity and grazing pressure
Selection of sown pastures better adapted to higher temperatures and water constraints
Provision of additional nitrogen through sown legumes
Provision of urea and phosphates directly to stock via reticulation or blocks
Greater utilisation of strategic spelling
Introduction of responsive stocking rate strategies based on seasonal climate forecasting
Development of regional safe carrying capacities i.e. constant conservative stocking rate
Where appropriate, development of software to assist pro-active decision making at the on-farm scale
Managing climate change risks – managing pests, disease and weeds
Improve pest predictive tools and indicators
Improve quantitative modelling of pests to identify most appropriate time to introduce controls
Increased (but cautious) use of biological and other controls
Increased use of insect traps for sentinel monitoring and for population control
Incorporation of alternative chemical and mechanical methods for reducing woody weeds
Acceptance that the biota may change
Managing climate change risks – animal husbandry and managing health
Selection of animal lines that are resistant to higher temperatures
Modify timing of mating based on seasonal conditions
Modify timing of supplementation and weaning
Increase use of trees as shading and reducing wind erosion

ACKNOWLEDGEMENTS

This paper summarises work undertaken over many years in conjunction with many researchers. Their input is gratefully acknowledged. Some of the research was conducted for projects with the Australian Greenhouse Office, the Climate Variability in Agriculture Program and the Rural Industries Research and Development Corporation. We thank Dr Kate Harle for her comments on the manuscript.

REFERENCES

Abel, N., Langston, A., Ive, J., Tatnell, B., Howden, S.M. and Stol, J. (2002). Institutional change for sustainable land use: A participatory approach from Australia. *In* 'Complexity and Ecosystem Management: The theory and practice of multi-agent systems.' (Ed M.A. Janssen). Edward Elgar, Cheltenham, UK, pp. 286-342.

Archer, S., Schimel, D.S. and Holland, E.A. (1995). Mechanisms of shrubland expansion: land use, climate or CO_2? *Clim. Change* 29: 91-100.

Bond, W.J., Midgley, G.F. and Woodward, F.I. (2003). The importance of low atmospheric CO_2 and fire in promoting the spread of grasslands and savannas. *Glob. Change Biol.* 9: 973-982.

Dunlop, M. and Howden, M. (2003). Biodiversity and climate change in Australia. Proceedings of '*Climate impacts on Australia's natural resources: current and future challenges*', Surfers Paradise, 25-27 November. Standing Committee on Natural Resource Management. pp24-25.

Gunderson, L., Holling, C.S. and Light, S. (1995). Barriers and bridges to the renewal of ecosystems and institutions. Columbia University Press, New York.

Hall, W.B., McKeon, G.M., Carter, J.O., Day, K.A., Howden, S.M. and Scanlan, J.C. (1998). Climate change in Queensland's grazing lands: II. An assessment of the impact on animal production from native pastures. *Rangeland J.* 20: 177-205.

Howden, S.M., Ash, A.J., Barlow, E.W.R., Booth, T., Charles, S., Cechet, R., Crimp, S., Gifford, R.M., Hennessy, K., Jones, R.N., Kirschbaum, M.U.F., McKeon, G.M., Meinke, H., Park, S., Sutherst, R., Webb, L. and Whetton, P.J. (2003). An overview of the adaptive capacity of the Australian agricultural sector to climate change – options, costs and benefits. Report to the Australian Greenhouse Office, Canberra, Australia, pp 157.

Howden, S.M., Hall, W.B. and Bruget, D. (1999). Heat stress and beef cattle in Australian rangelands: recent trends and climate change. *In* 'People and Rangelands: Building the Future.' (Eds D. Eldridge and D. Freudenberger). *Proceedings of the VI International Rangelands Congress*, July 1999, Townsville, Australia. pp. 43-45.

Howden, S.M., Moore, J.L., McKeon, G.M. and Carter, J.O. (2001). Global change and the mulga woodlands of south-west Queensland: greenhouse emissions, impacts and adaptation. *Env. Int.* 27: 161-166.

IPCC (2001). Climate Change 2001: The scientific basis. (Eds J.T. Houghton, Y. Ding, D.J. Griggs, M., Noguer, P.J. van der Linden and D. Xiaosu). Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, UK. pp. 944.

Kriticos, D.J., Sutherst, R.W., Brown, J.R., Adkins, S.W. and Maywald, G.F. (2003). Climate change and the potential distribution of an invasive alien plant: *Acacia nilotica* spp. *indica* in Australia. *J App. Ecol.* 40: 111-124.

Lilley, J.M., Bolger, T.P., Peoples, M.B. and Gifford, R.M. (2001). Nutritive value and the dynamics of *Trifolium subterrraneum* and *Phalaris aquatica* under warmer, high CO_2 conditions. *New Phytologist* 150: 385-395.

McKeon, G.M., Howden, S.M., Abel, N.O.J. and King, J.M. (1993). Climate change: adapting tropical and subtropical grasslands. *In* 'Grasslands for our world.' (Ed. M.J. Baker) SIR Publishing, Wellington, NZ.

Petit, J.R., Jouzel, J., Raynaud, D., Barkov, N.I. and Barnola, J.M. (2000). Climate and atmospheric history of the past 420000 years from the Vostok ice core, Antarctica. *Nature* 399: 429-436.

Scholes, R. and Howden, M. (2003). Rangeland vulnerability and adaptation in a changing world: a review. *In* 'Rangelands in the new millennium' (Eds. N. Allsopp, A.R. Palmer, S.J. Milton, K.P. Kirkman, G.I.H. Kerley, C.R. Hurt, and C.J. Brown), Proceedings VIIth International Rangelands Congress, 26 July-1 August, Durban, South Africa, 1021-1029.

Stokes, C.J., Ash, A.J. and Holtum, J. (2003). Ozface: Australian savannas free air carbon dioxide enrichment facility. *In* 'Rangelands in the new millennium' (Eds. N. Allsopp, A.R. Palmer, S.J. Milton, K.P. Kirkman, G.I.H. Kerley, C.R. Hurt, and C.J. Brown), Proceedings VIIth International Rangelands Congress, 26 July-1 August, Durban, South Africa, 1097-1099.

Sutherst, R.W. (1990). Impact of climate change on pests and diseases in Australasia. *Search* 21:

230-232.

Sutherst, R.W. (2001). The vulnerability of animal and human health to parasites under global change. *Int. J. for Parasitology* 31: 933-948.

Wand, S.J.E., Midgley, G.F., Jones, M.H. and Curtis, P.S. (1999). Responses of wild C_4 and C_3 grass (Poaceae) species to elevated atmospheric CO_2 concentration: a meta-analytic test of current theories and perceptions. *Glob. Change Biol.* 5: 723-741.

Wilson, J.R. (1982). Environmental and nutritional factors affecting herbage quality. *In* 'Nutritional limits to animal production from pastures.' (Ed. J.B. Hacker). CAB International, UK, pp. 111-131.

van Jaarsveld, A.S., Midgley, G.F., Scholes, R.J. and Reyers, B. (2003). Conservation management in a changing world. *In* 'Rangelands in the new millennium' (Eds. N. Allsopp, A.R. Palmer, S.J. Milton, K.P. Kirkman, G.I.H. Kerley, C.R. Hurt, and C.J. Brown), Proceedings VIIth International Rangelands Congress, 26 July-1 August, Durban, South Africa, 1040-1051.

FRAGMENTATION OF AUSTRALIAN RANGELANDS: RISKS AND TRADE-OFFS FOR LAND MANAGEMENT

C.J. Stokes [1], *A.J. Ash* [2] *and R.R.J. McAllister* [1]

[1] CSIRO, Sustainable Ecosystems, Davies Laboratory, PMB PO Aitkenvale Q 4814
[2] CSIRO, Sustainable Ecosystems, 306 Carmody Rd, St Lucia Q 4067

ABSTRACT

Land policy and legislation have been the major factors driving fragmentation of Australian rangelands. At the regional scale, fragmentation of rangelands has facilitated the development of private land rights, promoted the development and intensification of the pastoral industry, and encouraged settlement and growth of rural communities. But these changes have also had negative consequences in disrupting ecosystem functions associated with spatial connectedness, compromising enterprise economics and putting pressure on rangeland resources. Declining terms of trade and current pastoral property sizes, are both constraining the viability of present-day cattle production enterprises, leading to pressures to consolidate enterprises and intensify production systems. We explore some of the benefits that are expected from increased infrastructure development together with the trade-offs from the unintended consequences of internal property fragmentation.

INTRODUCTION

Arid and semi-arid landscapes, such as Australia's rangelands and savannas, are characterized by low levels of resources for plants and animals, and these resources are usually patchily distributed in time and space. This presents challenges for those seeking a livelihood in these systems. Traditionally, humans and herbivores have been able to exploit spatial heterogeneity to offset temporal variability in resource availability, with animals migrating to make use of favourable patches in the environment and human cultures adopting similar nomadic behaviour. The adoption of western-style, sedentary, intensified land uses has disrupted these large-scale spatial processes and landscapes have become fragmented into discrete parcels of land with diminished interactions between them. This has increased the exposure of land users to risks of temporal variation by denying them the opportunity to take advantage of more favourable parts of the landscape when local conditions are adverse (Boone and Hobbs 2003). Climatic variation in Australia's rangelands is particularly high and presents a major challenge to land managers. In addition to biophysical variation, the socio-economic climate is also in a continual state of flux with changing agricultural markets, changes in societies' values and expectations for rangelands and changes in agricultural practices (Holmes 1996, Ash and Stafford Smith 2003). In fragmented landscapes, land managers have to deal with these continually shifting challenges within the confines of their individual land units.

PROCESSES OF RANGELAND FRAGMENTATION

Land fragmentation, which has accompanied the pastoral development of rangelands, is defined here as the process by which spatial connectivity within a landscape is eroded and discrete land units become increasingly disassociated from each other. The fragmentation of rangelands, following settlement and subsequent development, can be thought of in terms of five elements (Fig. 1):

Resource Excision - Early land development is restricted to favourable regions in the landscape within which key resources are concentrated (such as permanent water sources, riparian areas and pastures with good forage). These are appropriated first, with land that is suitable for intensive uses being removed for other uses, while key grazing resources are commandeered to effectively provide exclusive access to surrounding, poorer-resource areas. Initial land use is therefore concentrated around naturally-occurring key resources in the overall landscape, much of which remains unutilized or lightly utilized. At this stage, utilized patches of land are fragmented within the landscape, with the patchiness of land use reflecting the heterogeneity in resource distribution and access to transport networks and markets.

Land Use Homogenisation - With development of regional and property infrastructure (especially artificial water points), resource access and land use across the region becomes more uniform, providing greater opportunities for regional fragmentation of pastoral properties (see Abbott and McAllister 2004, these proceedings).

Regional Scale Fragmentation - As development across the region provides a more uniform spread of resources, it becomes possible for larger properties to be subdivided, with the increase in infrastructure development offsetting the smaller sizes of the new properties.

Property Scale Fragmentation - Economic pressures to intensify production lead to the increased development of water points and fencing, with internal fragmentation of properties into smaller paddocks.

Consolidation - Properties are combined together into larger enterprises when individual properties are no longer large enough to support a viable business (because of excessive subdivision and/or declining terms of trade) (Ash *et al.* 2003).

These elements of land fragmentation could be considered to follow a rough sequence, with each in turn becoming progressively dominant over time (Fig. 2).

The development of Australia's rangelands, with accompanying land fragmentation, has lead to steady gains in pastoral production. But associated with this, land managers have also been exposed to greater risk from climatic variation, environmental degradation, and changing social and economic conditions. Here, we look at fragmentation in rangelands, using the Dalrymple Shire as an example, to assess the drivers of land fragmentation, the benefits and risks that arise, and the responses of land managers to these challenges and opportunities.

LAND FRAGMENTATION IN THE DALRYMPLE SHIRE

Shire Description

The Dalrymple Shire is situated in northeast Queensland and covers 66,709 sq km of the Burdekin River catchment. Weather patterns are affected by El Niño - Southern Oscillation cycles, which contribute to a high interannual variation in rainfall (CV% 30-48). Soils vary from infertile sandy duplexes to relatively nutrient-rich, self-mulching clays reflecting the heterogeneity in underlying geology, drainage patterns and other topographic features. This heterogeneity supports a variety of vegetation communities that differ in species composition, seasonality and forage production.

The Shire is predominantly state leasehold land (87%), with most freehold land restricted to urban centres and surrounding small rural residential and non-commercial grazing lots. The vast majority of the Shire is used for extensive beef production and cattle disposals in 1992/3 were valued at $51 million (Rogers 1998). Most pastoral enterprises are independent, family-run businesses that combine cattle breeding and fattening operations (Bortolussi *et al.* 2004a). The largest economic sector is mining (gold, base metals and dolomite), valued at $232 million.

Since European settlement, patterns of land use and tenure in northern Queensland have been strongly influenced by government policies and by events at local to global scales. Below, we briefly review how some of the factors associated with pastoral development have affected landscape fragmentation, the scale of land use and land requirements for viable enterprises.

Land Policy, Legislation & Tenure

The dominance in the Shire of leasehold land, with property rights dictated by lease conditions (QNRM 2001), has meant that land legislation, especially that pertaining to lease terms and conditions, has been a major policy instrument for influencing land use. Australian land legislation has historically been aimed at orderly allocation of land, encouraging settlement and land 'improvement', generating revenue, preventing monopolies, promoting social equity, and developing the rights of landholders in relation to the state (Hannam 2000).

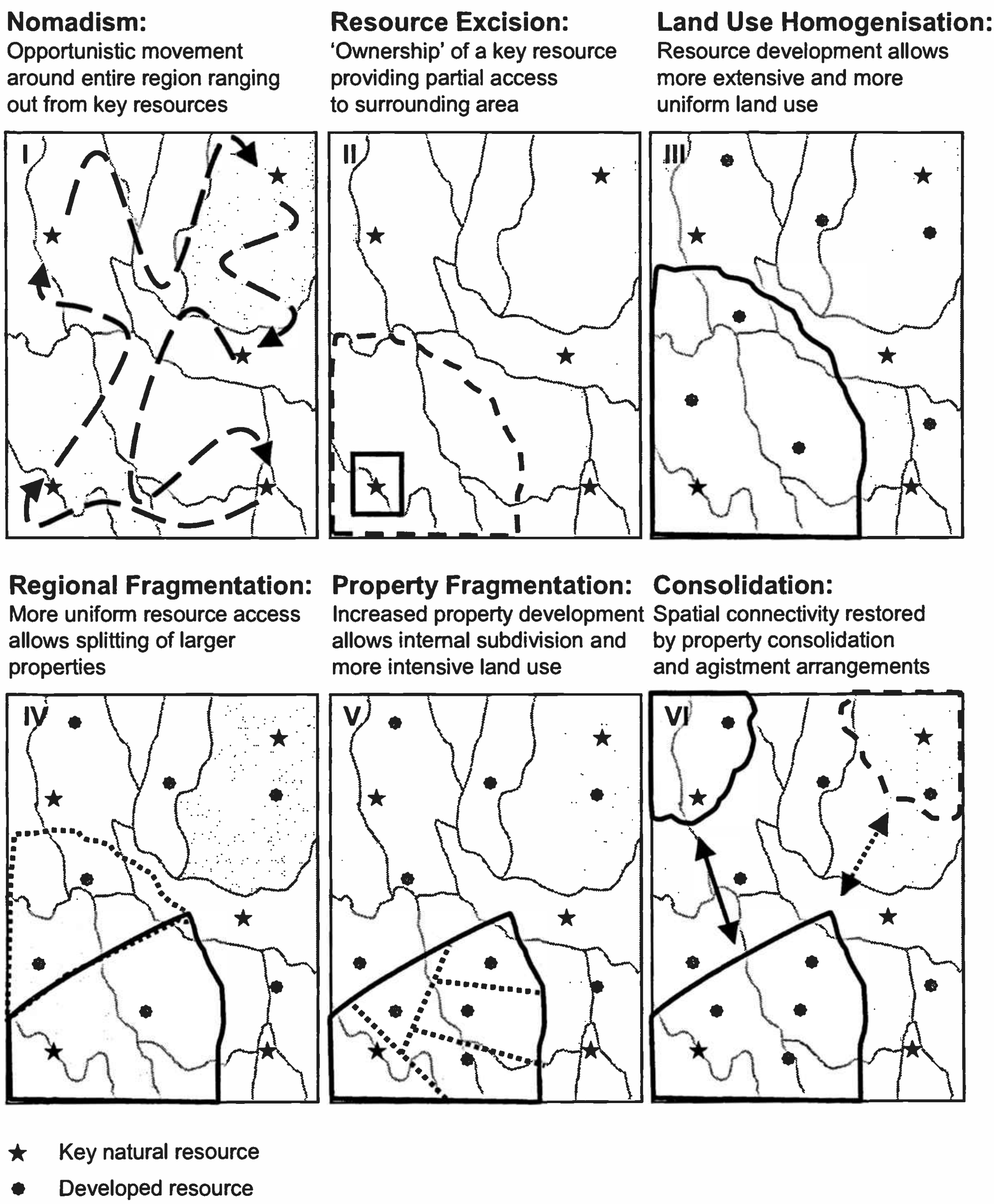


Figure 1. Processes of fragmentation and modes of land use in a heterogenous landscape during pastoral development.

European settlement of the Dalrymple Shire coincided with two events that stimulated early pastoral development; the discoveries of gold in the 1860s and 1870s and the separation of Queensland from New South Wales in 1859 (Holmes 1963). The Queensland Land Act 1860 promoted settlement by providing leases of 14 years with minimal lease fees. While the runs were relatively small, 6,600 to 26,700 ha, there was no limit on the number that could be held, as long as they were stocked to a quarter of their carrying capacity within nine months. The Crown Lands Act 1884 was enacted to promote a policy of closer settlement and it provided for parts of leases to be resumed. As a result, many small runs around Charters Towers and Ravenswood were acquired by ex-miners for dairying. A new Land Act was introduced in 1894 and, with subsequent revisions, it continued to support a policy of 'closer settlement', favouring the creation of smaller land lots for allocation to family-operators. One goal of the policy was to encourage the growth of rural communities.

During the 1950s, the Queensland 'populate or perish' strategy developed from a review of land settlement policy (Land Settlement Advisory Commission 1959). This review recognized the influence of property size on financial security, but sought to balance this against the requirement for increased rural population density for regional community viability (Day 2001). The expectation at the time was that agricultural enterprises would require assistance during establishment, but that they would later become self-sufficient as development and 'improvement' of the land increased its production potential. As an incentive for land development, lease terms were extended, security of tenure was emphasized, and costs of land development were recognized. This applied especially to the Brigalow Belt, which extends into the southeast of Dalrymple Shire, where land 'improvement' involved expensive tree clearing and sowing of pasture. The last notable fragmentation of properties in the Shire occurred during the post World War II period, when resumptions of land from large leases created several new smaller leases that were allocated by ballot. These properties generally remained large enough (40,000 - 50,000 ha) to support viable enterprises at the time.

REGIONAL FRAGMENTATION – IMPACTS & ADAPTATION

Property Size Constraints

The beef and sheep industries have been characterized by boom and bust cycles affected by changes in local and international markets and climatic variation. Favourable periods for the pastoral industry have often been characterised by overoptimistic expectations of the land's production potential (Allingham 1976), pressures for more intensive development, closer settlement and property subdivision. Downturns in the markets and weather have exposed the vulnerability of small enterprises. It has been proposed that fragmentation in rangelands continues until financial, ecological and social dysfunction become severe enough to initiate structural adjustment towards consolidated enterprises (bottom of the curve in Fig. 2), and that rangelands are most vulnerable to degradation at the time of these changes when stresses associated with rangeland fragmentation and small enterprise size are greatest (Passmore and Brown 1992, Ash *et al.* 2003). These pressures and consequent resource degradation have been well documented for the region (De Corte *et al.* 1994, Mortiss 1995). The Dalrymple Shire has not been suitable for sheep and has therefore avoided the excessive level of fragmentation, largely associated with the wool booms, that has been seen in some of the pastoral areas further south. Nevertheless, current property sizes in the Shire are still some of the smallest among the extensive beef producing areas in northern Australia (Bortolussi *et al.* 2004a).

Cost-Price Squeeze

In addition to declining property sizes, economic factors have contributed substantially to the reduced viability of pastoral enterprises. Estimates of the number of cattle required to maintain an economically viable, extensive pastoral enterprise have been steadily increasing over the past decades.

It is currently estimated that cattle properties in the Shire need to be able to carry 1,500 to 3,000 adult equivalents (Caltabiano *et al.* 1999, Roth *et al.* 1999). This reflects the declining terms of trade for the beef industry: while output prices for pastoral production have remained unchanged, input costs have risen by 1.9%/yr relative to the consumer price index (Centre for International Economics 1997). Hinton (1993) reported average rates of return for beef properties in the Dalrymple Shire of -1 to 3%, although beef prices were relatively low at the time of Hinton's report. In adapting to this cost-price squeeze, enterprises have little control over product prices and many have already streamlined input costs and production practices (Landsberg *et al.* 1998). There are thus strong pressures for enterprises to consolidate properties and/or intensify production systems (Fig. 2) (Ash *et al.* 2003).

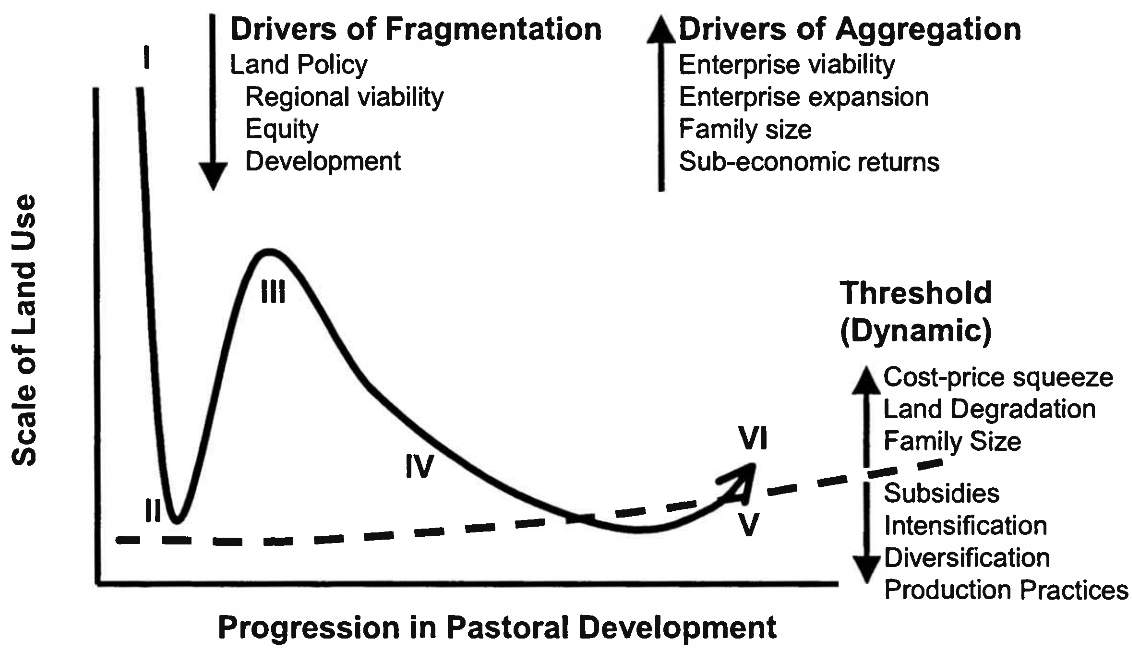


Figure 2. Effect of pastoral development on landscape fragmentation and the scale of land use (solid line). In recent times, there has been a general upward trend in the threshold for the minimum property size required to sustain a viable pastoral enterprise (dashed line). Roman numerals indicate when processes listed in Fig. 1 are dominant.

Business Consolidation

One of the main drivers for aggregating properties into larger enterprises is to generate efficiencies from the increased scale of production. There is evidence of increasing consolidation of pastoral properties across northern Australia, even amongst owner-operated (non-corporate) enterprises (Bortolussi *et al.* 2004a). Discussions with land managers in the Dalrymple Shire show that there is a wide range of reasons for combining pastoral properties into a single enterprise. Family size is an important driver for consolidation, and pastoralists with more than one child often want to expand their enterprises to provide opportunities for their children. In these cases, succession planning becomes an important consideration in structuring the business. Business partnerships between property owners (whether related or not) have at times been a useful means of pooling human and financial resources for mutual benefit. Careful selection of complimentary properties allows specialisation of production activities according to land type. There may be similar benefits if there are differences in weather patterns between properties, since stock can be moved between properties to match differences in forage availability, such as in the case of localized droughts. Ownership of several properties also offers the chance for opportunistic real estate transactions and personal business/lifestyle differences can affect preferences for multi-property or single property management structures.

Hinton (1993) found the 271 commercial grazing properties in the Dalrymple Shire to be amalgamated into 196 pastoral business entities. Properties ranged in size from 10,000 to 50,000 ha and carried 2,000 to 5,000 head of cattle (Rogers 1998). A recent survey showed that more than half of landholders in the Shire currently own more than one property, with an average of 2.2 properties each (Greiner *et al.* 2003). The average property size of those running a single property is 13,471 ha whereas the average individual property size in jointly-run properties is 40,259 ha, i.e., it appears that the larger properties are the ones being consolidated together. This is consistent with indications from owners of multiple properties that their preference for maintaining flexibility in their business structure is to deal only in properties that are tradeable as standalone entities. This would suggest that property units that have been over-subdivided are effectively removed from efficient, sustainable pastoral production.

PROPERTY FRAGMENTATION & INTENSIFIED PRODUCTION

Benefits of Property Infrastructure Development

The other response to pressures facing the pastoral industry has been a move towards more intensified production systems involving increases in property infrastructure, particularly water points and fencing (Bortolussi *et al.* 2004a). There are numerous benefits that are expected to flow from these developments, but the main aim has usually been to achieve more uniform utilization of pastures across the landscape. The availability of permanent water has been a major limitation on the spatial extent of land use by livestock, especially for European breeds of cattle that did not venture far from water points and riparian areas. On most properties today, the limited coverage of water sources contributes to uneven spatial utilization of paddocks (Pickup and Chewings 1988) and restricts the options for installation of new fences. Development of new water points remains a top priority for many land managers as a means to provide more uniform livestock access across properties.

Aside from distance to water, selective grazing by livestock in patches or preferred vegetation communities has also contributed to uneven grazing. Selective overgrazing can initiate a sequence where livestock progressively degrade one preferred vegetation type after another. In the past, most fencing was done for animal management reasons: to separate stock by type, to match stock types to the quality of pasture, to assist with mustering animals, to keep stock owned by different people apart, to manage cattle diseases and to control animal pests. But grazing, vegetation and land management objectives are starting to become more important considerations for fencing. With the development of new water infrastructure, opportunities are arising for fences to be used in more strategic ways. Much of this fencing has concentrated on controlling access to heavily-utilized riparian areas as a means of limiting land and pasture deterioration and controlling weeds. Fencing according to land type allows the intensity of use of preferred pastures to be controlled to prevent overgrazing, with stock being shifted to make better use of underutilized land types. For some sensitive vegetation types, controlling the timing of grazing can limit the impacts of grazing, while in other cases, periods of intensive grazing can be used to positive effect to control undesirable plants and promote desirable species. Internal subdivision of properties also allows for strategic spelling of pastures, and other stock movement systems for controlling the intensity, duration and timing of grazing. Where paddocks are small enough, this can be incorporated with strategic use of fire in management, by allowing fuel loads to build up and controlling when livestock are reintroduced after pastures start to grow again. Management systems based on these principles have been used to address the problem of patch grazing (Andrew 1986), and are also being tested for controlling undesirable plants.

We have described how the subdivision of properties into smaller paddocks and associated increased control over animal movement create a range of options for positive intervention in the management of rangelands. But with these opportunities come the requirement for increased management action in planning infrastructure development and stock movements. This has given rise to the development of a range of grazing and management systems within which to plan and exercise these options. While views on the merits of various intensive management systems are often passionately held, they have proved difficult to validate (Holechek *et al.* 2000). There are a number of factors associated with intensified production systems that could all be beneficial to overall enterprise management: water point development provides the possibility of more uniform livestock access across a property, even without additional fencing; fencing provides opportunities for greater control of the location, intensity, duration and timing of grazing, and smaller paddock sizes may improve utilization even without elaborate rotational grazing systems (Hart *et al.* 1993); formalized management and grazing systems provide decision-making principles for stock movements and other aspects of enterprise planning and evaluation (Earl and Jones 1996); and closer interaction of managers with enterprise resources (livestock, land, financial and human) can improve their familiarity with the overall state of their enterprise making it easier to detect warning signs of problems and intervene earlier. It is difficult to determine the relative contributions of these different elements to overall enterprise performance, but doing so would be extremely valuable for planning, implementing and improving efficient and sustainable intensified production systems.

Risks Associated with Rangeland Fragmentation

If a 100 ha paddock can sustainably support 10 head of cattle, how many head of cattle can a 10,000 ha paddock support? This question is deceptively simple, but exposes the complex nature of the effect of the scale of land use on spatial interactions of herbivores with their environments (Roshier and Nicol 1998). We have already looked at the ways in which smaller paddock sizes may benefit livestock production and other aspects of enterprise management, but now we address some of the possible trade-offs and unintended negative consequences of intensification that should also be taken into account.

Where herbivores are free to exploit landscapes at large scales, heterogeneity has the potential to act as a spatial buffer to offset seasonal dry periods and droughts (Boone and Hobbs 2003). This spatial buffering would be expected to be strongest where the mix of vegetation patches within a paddock responds differently to weather events (such as seasonal cycles, droughts, frosts or wet periods) and in

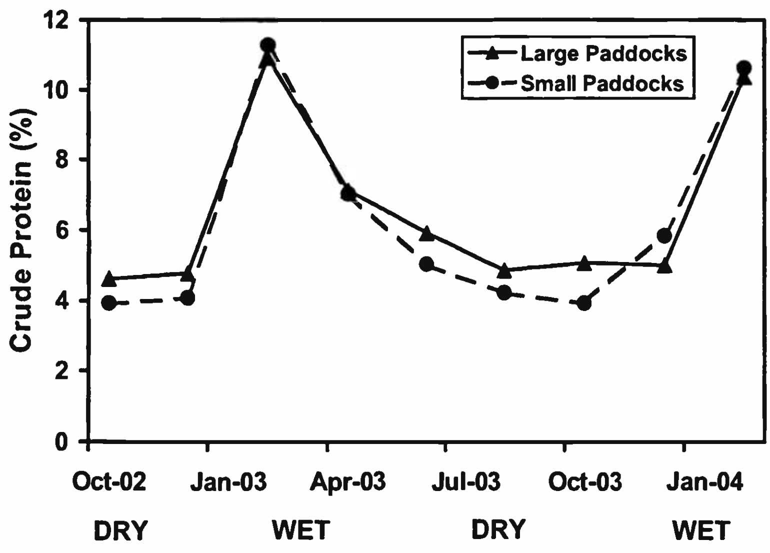


Figure 3. Seasonal variation in cattle diet quality (as measured by faecal near infrared spectroscopy) for 30 large (> 2200 ha) and 30 small (< 2200 ha) paddocks in the Dalrymple Shire.

a manner that alters the relative values of the different patches as forage sources for herbivores. These spatial interactions would be lost with fragmentation. Restrictions on animal movement could potentially have negative consequences for animal nutrition by reducing the accessible diversity of vegetation for selection and diet maintenance when forage quality is poor. Preliminary, illustrative results from a study in the Dalrymple Shire are consistent with this predication (Fig. 3). If this is the case, animal performance would suffer in smaller paddocks, or costs would be incurred in the requirement for extra feed supplements. It has similarly been suggested that heterogeneity in large paddocks acts as a buffer against the effects of increased stocking rate, with a reduced density-dependent decline in individual animal performance in large, complex paddocks than small or homogenous ones (Ash and Stafford Smith 1996, Roshier and Nicol 1998).

There are also biodiversity implications for intensified land use. Current patterns of land use provide a diversity of utilization rates ranging from very heavily grazed patches that promote disturbance- and grazing-adapted species near water points, to very lightly used areas with poor water access that provide refugia for grazing sensitive species (James *et al.* 1999). With intensified land use, these refugia could be lost and other arrangements would have to be made for the conservation of these species. The increased availability of water sources could also contribute to increases in populations of native and introduced animals, increasing utilization pressure on pastures and creating other management problems.

Intensified grazing systems pose a set of risks too. The level of improvement in long-term, sustainable beef production is uncertain and the level of infrastructure development at which development costs exceed the returns on investment is not clear (Holecheck *et al.* 2000). This poses financial risks, and the short-term financial impact of the costs of development and increased herd size need to be carefully managed, even if future gains are assured. Increased property development provides the means to greatly increase stocking rates in the short-term, even though these stocking levels are not sustainable in the long-term, increasing the potential for environmental damage if proper management restraint is not exercised. Even when a property as a whole is not overstocked, the distribution of animals needs to be constantly managed according to the changing conditions in each paddock; otherwise individual paddocks can be overgrazed. The spatial interactions of freely-moving herbivores with heterogenous landscapes result in complex movement patterns as vegetation is produced and consumed across the landscape (Bailey *et al.* 1996). In fragmented landscapes, these 'automatic' movements are lost, but there are increased opportunities for them to be controlled 'manually'. This increases both the opportunities for positive management intervention and the damaging consequences of incorrect decisions, requiring a greater level of skill and understanding from land managers: development of human capacity would have to match efforts to improve the productive capacity of the land. There have been warnings of unforseen negative outcomes of some high-risk management strategies aimed at intensifying production (Holecheck *et al.* 2000). Many of the elements of intensified production systems are, in effect, equivalent to 'disabling the environmental safety switches' so that environmental processes can be switched from 'automatic' to 'manual' to gain some extra performance. Do we know enough to decide which switches we can flip and how to work with them off? A holistic regional approach to intensification also needs to consider the human dimension of the risks associated with our capacity to manage the environment 'with the safety switches off'.

CONCLUSIONS

Policies governing the development of Australia's rangelands have had to strike a balance between achieving sustainable communities and economies at the regional level, and achieving sustainability at the enterprise level. These goals have often been viewed to be in conflict, with the legacy of 'closer settlement' contributing to the challenges faced in achieving sustainability at the enterprise level today. An added complexity is that there are continual fluctuations and changes in the biophysical and socio-economic climate so, to stay viable, even enterprise structures that are currently successful cannot remain rigid. Small and/or heavily utilized properties have less flexibility to adjust to these changes and are therefore exposed to greater risk compared to larger enterprises with moderate utilization rates. Many pastoralists may be more concerned about managing risk and maintaining flexibility than optimizing production for the prevailing conditions (Bortolussi 2004a).

With the current trend towards intensification of production, it is important to acknowledge some of the accompanying uncertainties and trade-offs, such as the disruption of spatial buffering provided by landscape heterogeneity. There are a number of important questions that need to be answered. Which elements of landscape heterogeneity, connectedness and fragmentation are beneficial for pastoral systems? Landscape patchiness could have both positive and negative implications for land management (Ash *et al.* 2003). It may be that heterogeneity provides a benefit only when there is complementarity in seasonal livestock preferences and forage values of different vegetation types. Whereas, in situations where there is a consistent animal preference for a particular vegetation type through all seasons, it could be better to subdivide the different vegetation types into simplified management units for separate, specialised management. What is the optimum level of fragmentation and internal development within properties? What are the relative positive and negative contributions of the different elements of intensification (water points, fencing, management systems and resource familiarity) to overall enterprise performance and sustainability? And what role can social networks, such as agistment arrangements, play in restoring connectedness and resilience to pastoral regions?

Better understanding of these benefits and trade-offs could allow some of the negative effects of fragmentation to be minimized in intensified production systems, while some of the positive effects of heterogeneity and connectedness could be restored, contributing to the robustness of pastoral enterprises and their capacity to adapt to changes in the future.

ACKNOWLEDGEMENTS

Many of the concepts relating to rangeland fragmentation have been developed in collaboration with our research partners in the SCALE project. The project is supported by the US National Science Foundation Biocomplexity Program. We are grateful to the landholders participating in this study for their involvement and for sharing their knowledge of the history of pastoral development in the Dalrymple Shire and on their properties.

REFERENCES

Allingham, A. (1977). "Taming the Wilderness": the first decade of pastoral settlement in the Kennedy District. PhD thesis. James Cook University.

Andrew, M.H. (1986). Use of fire for spelling monsoon tallgrass pasture grazed by cattle. *Tropical Grasslands* 20: 69 – 78.

Ash, A., Gross, J. and Stafford Smith M. (2003). Scale, heterogeneity and secondary production in tropical grasslands. Proceedings of the VIIth International Rangelands Congress, pp 569 – 579.

Ash A.J. and Stafford Smith, M. (1996). Evaluating stocking rate impacts in rangelands: animals don't practice what we preach. *The Rangeland Journal*. 18: 216 – 243.

Bailey, D.W., Gross, J.E., Laca, E.A., Rittenhouse, L.R., Coughenour, M.B., Smith, D.M. and Simms, P.L. (1996). Mechanisms that result in large herbivore grazing distribution patterns. *Journal of Range Management*. 49: 386 – 400.

Boone, R.B. and Hobbs, N.T. (2003). Lines around fragments: effects of fencing on large herbivores. Proceedings of the VIIth International Rangelands Congress, pp. 580 – 591.

Bortolussi, G., McIvor, J.G., Hodgkinson, J.J., Coffey, S.G. and Holmes, C.R. (2004a). The northern Australian beef industry, a snapshot: 1. Regional enterprise activity and structure. *Australian Journal* *of Experimental Agriculture*. In press.

Bortolussi, G., McIvor, J.G., Hodgkinson, J.J., Coffey, S.G. and Holmes, C.R. (2004b). The northern Australian beef industry, a snapshot: 4. condition and management of natural resources. *Australian Journal of Experimental Agriculture*. In press.

Caltabiano, T., Hardman, J.R.P. and Reynolds, R. (1999). Living area standards. Queensland Department of Natural Resources, Coorparoo.

Centre for International Economics. (1997). Sustainable natural resource management in the rangelands. Centre for International Economics, Canberra & Sydney.

Day, D. (2001). *Claiming a continent: a new history of Australia*. Harper Collins, Sydney.

De Corte M.W.M., Barry E.V., Bright M.J., Cannon M.G. and Scanlan J.C. (1994). Land degradation in the Dalrymple Shire, a preliminary assessment. Methods and results. Project report Q093023, Queensland Department of Primary Industries, Brisbane.

Greiner, R., Stoeckl, N., Stokes, C., Herr, A. and Bachmaier, J. (2003). Natural resource management in the Burdekin Dry Tropics: social and economic issues. CSIRO, Townsville.

Hannam, I. (2000). Policy and law for rangeland conservation. *In* 'Rangeland desertification.' (O. Arnalds and S. Archer). Kluwer Academic Press, Dordrecht.

Hart, R.H., Bissio, J., Samuel, M.J., and Waggoner, J.W. Jr (1993). Grazing systems, pasture size, and cattle grazing behavior, distribution and gains. *Journal of Range Management*. 46 : 81-87.

Hinton, A.W. (1993). *Economics of beef production in the Dalrymple Shire*. Queensland Department of Primary Industries, Brisbane.

Holechek, J.L., Gomes H., Molinar, F., Galt, D. and Valdez R. (2000). Short duration grazing: the facts in 1999. *Rangelands* 21: 18-22.

Holmes, J.H. (1997). Diversity and change in Australia's rangeland regions: translating resource values into regional benefits. *The Rangeland Journal*. 19: 3 – 25.

Holmes, J.M. (1963). *Australia's open north*. Angus and Robertson, Sydney.

James C.D., Landsberg, J. and Morton, S.R. (1999). Provision of watering pints in the Australian arid zone: a review of effects on biota. *Journal of Arid Environments*. 41:87-121.

Land Settlement Advisory Commission (1959). *Report on progressive land settlement in Queensland*. State of Queensland, Brisbane.

Landsberg, R.G., Ash, A.J., Shepher, R.K. and McKeon, G.M. (1998). Learning from history to survive in the future: management evolution on Trafalgar Station, north-east Queensland. *The Rangeland Journal*. 20: 104 – 117.

Mortiss, P.D. (1995). The environmental issues of the Upper Burdekin catchment. Project Report Q905017, Queensland Department of Primary Industries. Brisbane.

Passmore, J.G.I. and Brown, C.G. (1992). Property size and rangeland degradation in the Queensland mulga rangelands. *The Rangeland Journal*. 14: 9 – 25.

QNRM (Queensland Department of Natural Resources & Mines) (2001). *Managing State rural leasehold land: a discussion paper*. State of Queensland, Coorparoo.

Rogers, L.G., Cannon, M.G., and Barry, E.B. (1998). *Land resources of the Dalrymple Shire*. Queensland Department of Primary Industries, Brisbane.

Roshier, D.A., and Nico, H.I. (1998). Implications of spatio-temporal variation in forage production and utilisation for animal productivity in extensive grazing systems. *The Rangeland Journal*. 20: 3 – 25.

Roth, C., Aldrick, J., Ash, A., Hook, R., Novelly, P., Orr, D., Quirk, M. and Sallaway, M. (1999). The North Australia Program: NAP Occasional Paper No. 4. CSIRO, Townsville.

PRECISION PASTORALISM – THE KEY TO ENVIRONMENTAL RISK MANAGEMENT

Tony Thompson

Afterhours Ag, "Prattenville Irrigation", Bourke, NSW 2840

In 2001 I diversified our agricultural operation to include livestock production. We are based on the flood plains of the Darling River in the Bourke district of Western NSW. Unfortunately, or perhaps fortunately, that move into livestock coincided with the worst drought in living memory. In an attempt to maintain our core breeders we suffered horrendous stock losses and inflicted severe stress on our natural resource. I concluded that if I wanted an acceptable profit margin from livestock production, serious changes to the way I approached our grazing operation needed to be made.

We have three basic land types on our properties. A heavy cracking grey clay, being the low lying flooded country, a softer textured cracking grey clay, which surrounds the lower lying areas and the red ridges consisting of a non cracking red clay.

The pastures we have inherited are in a degraded state. Poor populations of perennial summer grasses created by years of overgrazing have resulted in heavy infestation of Black Roly Poly, particularly in the grey cracking clays. Copperburrs and saltbushes make up a large percentage of our pasture base, particularly on the red ridge country. Medics are a carpet in good autumns and winters.

The median rainfall for Bourke is 338 mm. Although rainfall is slightly summer dominant, it is highly variable all year round, especially in the summer and autumn months.

My fundamental objective as a farmer is to turn water into dollars. The challenge is how can we improve the efficiency or effectiveness of the water we receive to maximise profitability, but maintain or improve our resource health, which I consider the real production driver.

Currently the main focus of our business is cotton production. Ten years ago, if a cotton producer achieved a yield of 10 bales/ha it was considered an incredible result. In 2003 a farmer grew a yield of 15 bales/ha. This result has been achieved on very similar inputs of water and nutrition. Breeding has played a role, but the key differences are precision and objective decision-making.

Data collection has become an essential ingredient in cotton production and now drives the decision making process of growers. Targets or thresholds have been established based on research, and when triggered, disciplined decisions are implemented.

In contrast, when I look at rangeland grazing, gut feel or subjective decision-making makes up the majority of decisions. Performance is similar to that achieved 20-30 years ago and in a lot of cases considerably less.

Technology is now accessible to assist rangeland graziers manage their operations using objective measurement. Equipment is now available to assist in managing our resource using computer modelling and to manage our livestock on an individual basis. We are currently implementing this technology, and designing a management system, which enables us to scrutinise our grazing operation in precise detail.

In my view, the future for Risk Management in all agricultural enterprises revolves around the collection of data, the establishment of thresholds and the discipline to implement actions when thresholds are triggered.

I have identified Natural Resource Management and Animal Management as the two areas we wish to collect data and set thresholds in our grazing enterprise.

NATURAL RESOURCE MANAGEMENT

My system for managing our natural resources involves measuring standing dry matter and modelling future pasture growth and quality based on soil moisture and projected climate data.

Before any analysis, it is critical that we better understand the natural resource we manage. We have done this by accurately mapping the physical features of the property using GPS. Layers we have mapped include boundary fences, internal fences, rivers, water points, pipelines, buildings, yards and roads. GPS mapping software is a tremendous tool in planning infrastructure for maximum production and designing a long-term farm plan.

Variability of pasture type, under rangeland conditions is the major obstacle in estimating available feed and its quality. This variability can be greatly reduced, by identifying the different land systems in each paddock. Using satellite imagery and mapping software we have been able to identify these key land types on our property and calculate the area for each paddock.

Importing our land types into the GRASP Native Pasture Production Model gives us the capacity to project pasture growth for each of these land types. This model can be run using a number of different weather scenarios based on criteria such as average weather data, Southern Oscillation Index or Sea Surface Temperatures.

Regular monitoring (weekly on paddocks being grazed – monthly on land being rested) of actual standing dry matter and quality, compared to the modelled data will help to fine tune the model. This monitoring also provides backup to modelled projections and is vital in identifying elements, which may not be predicted in the model run and to initiate changes in management to compensate.

Long-term improvement of our pasture is a key objective of our business. We have inherited pastures in a degraded state with low numbers of perennial grasses and high infestations of unpalatable annuals.

Permanent monitoring sites have been established on each land system on each property. Vegetation targets for each land system are being established. We aim to monitor these sites twice yearly, in summer and winter. A database of species, densities, ground-cover % and photos are being developed which we will use to compare to our targets. A review is carried out on our grazing strategy following each monitoring period to ensure we are not adversely affecting our chances of achieving our long-term vegetation targets.

REMOTE INDIVIDUAL ANIMAL MANAGEMENT

My desire in the management of our livestock is to be constantly measuring every animal's liveweight and strategically measuring other characteristics on representative numbers of each mob.

Individual animal management offers tremendous productivity gains for any grazing enterprise. The introduction of the electronic ear tag, scanning equipment and telemetry equipment gives us the ability to remotely identify and measure each animal's performance under rangeland conditions as it enters a water point.

In the system we are developing, all waters are isolated by a trap-yard. Only the waters in an area of the paddock we are grazing are open. A remote electronic reader, weighbridge and drafter are at the entrance to these water points. As stock enter the water point they are weighed. This information is logged on computer and information is downloaded to our office via remote telemetry.

The automatic drafter combined with the electronic ear tag gives us the ability to draft animals into a holding paddock as they enter the water point. The drafter can be preset to any criteria.

Some data collection for better decision making may not need to be done on an individual animal basis. For example, to estimate calving percentages or fleece development, a relative sample, randomly selected, of animals from a mob can be automatically drafted into a separate portable yard adjoining a water point and tested.

Remote individual animal management also enables us to box mobs together but still manage them either individually or in their traditional mobs. This gives us larger mob sizes, which encourages less selective grazing and improved pasture utilisation.

Through this technology, we can obtain a wealth of information and perform a number of operations without physically having to handle the animals.

CONSIDERATIONS FOR RISK MANAGEMENT

The data collection processes we are implementing offer us the potential to scrutinise our grazing operation to levels previously unthought of. It offers us risk management solutions for environment, animal and financial performance.

The challenge is to establish a truly Integrated Management System, which interrogates the data identifying the productive spread and health of your animals and rangelands which is compared to strategic targets and when triggered, initiates a disciplined decision process. Some examples of the process are in the table below.

MEASUREMENT	THRESHOLD	ACTION
Natural Resource		
Ground Cover	< 30% ground cover	Remove all animals
Perennial grass population	> 2 / square meter	Increase utilisation to 70%
Animal Performance		
Decrease in daily liveweight of mob	Pasture losing quality & Animals losing value	Sell
Decrease in daily liveweight of individuals	> 15% below mob average	Auto draft and analyse
Financial Performance		
Commodity price falling	Projected profit drops below 10%	Fix price on minimum 50% of guaranteed production
Meat forward contract	Daily growth rate less than projected 2 months prior to delivery.	Advise buyer with new projections. If need be – cash out contract.

No risk management strategy is complete without accurately knowing your cost of production and profit levels. Precision grazing technology enables us to view business performance daily, on an individual animal, land type or paddock basis.

Marketing tools such as the Eastern Cattle Indicator and the Mutton Indicator are available which enable us to identify opportunities. Sydney and Macquarie wool and cattle futures are also a good source for market trends and potential hedging tools. It is my objective to forward market our livestock, and we are currently communicating our system with processors and other potential purchasers.

MANAGING CLIMATE RISK

Knowing the water holding capacity of our soils and knowing the quantities of dry matter, which can be produced from that moisture, can reduce climate risk. The simple use of historical average weather data offers relatively accurate forecasting for temperature and evaporation. Running a pasture growth model based on soil water and forecasted temperatures and evaporation is also reasonably accurate.

Our current grazing strategy is to buy stock based on pasture availability from current soil water. We make no assumption for further rainfall. Our purchase criteria are based on a % return on investment. When soil moisture is depleted and before animal performance is declining, we aim to sell. If further rainfall occurs we reassess each mob. If they continue to show a good return on investment they will be held beyond their initial intended sale date, and a new sale date is established.

Seasonal rainfall forecasting may be useful in assisting in purchase decisions. For example, if the projections are for dryer conditions, we may tend to target a fattening strategy over a breeding strategy.

We have not used seasonal rainfall forecasts for decision-making in any of our agricultural enterprises to date. I see a reasonable correlation to SOI and Darling River flows, which may impact our cotton planting decisions in September. There is also a good correlation between SOI in June to August and potential rainfall for the coming season in our area of NSW.

CONCLUSION

Risk management is about protecting the downside and as we know there is plenty of downside in agriculture. Precision grazing technology enables us to implement a management system based on data collection, which provides us with information which can make the decision making process much clearer.

Once the system is established discipline is paramount. When thresholds are triggered, actions must be implemented without hesitation. Sometimes when we encounter the unexpected, these decisions will involve pain, but the pain will be bearable, and when an opportunity arises again, we will be ready to strike.

Long-term sustainability of our natural resource is an important component of our risk management system. The establishment of targets for the health of our rangelands is an important goal. Our grazing strategy must always take these goals into account.

POLICY CONTRIBUTIONS TO ENVIRONMENTAL RISK MANAGEMENT – MATCHING POLICY TO THE RANGELAND ENVIRONMENT

Ronald B. Hacker

NSW Agriculture, Trangie Agricultural Research Centre, Trangie, NSW 2823

ABSTRACT

It is argued that current policy settings in relation to land administration, drought, taxation and other financial measures (e.g. Farm Management Deposits) do not provide an adequate framework for the management of environmental risk in the rangelands. A particular deficiency is the lack of policies or measures that discourage short term profit taking and promote longer term environmental outcomes, directly relate assistance to those outcomes, and actively encourage learning and adaptation by land managers. Incentive-based policies have the potential to redress these deficiencies and are the subject of much current interest. One approach currently under evaluation in the Western Division of NSW is described, in which payments are related to the achievement of ground cover targets.

INTRODUCTION

At the Centenary Symposium of this Society Hacker *et al.* (2000) argued that the 'mainstream' view of rangeland management, based on the economic and ecological benefits of conservative stocking, frequently failed to capture the realities of the pastoral economy. An alternative model, in which pastoralists choose among management options and select those that maximise the net present value of production subject to certain assumptions about discount rates, seemed to provide a better explanation of the range of management styles that may be observed in practice. A consequence of this model is that short term exploitation of the resource is often logical from a private perspective since the benefits of more conservative management accrue only in the long term. We argued that under this model increased research and extension effort may not greatly change pastoralists' management strategies, that the market did not operate efficiently to maximize both public and private good, and that a case existed to broaden the range of policy instruments to ensure that land use conformed to community expectations.

Before considering what those instruments might be, it is appropriate to review briefly the historical policy settings, how well they have matched the rangeland environment and what benefits they have delivered in terms of environmental risk management.

THE POLICY ENVIRONMENT

Land administration

In all rangeland States, the historical approach to the administration of pastoral leases has included, in addition to general obligations to preserve the resource, various prescriptive management requirements (e.g. development conditions, maximum or minimum stocking rates) and a regulatory system largely dependent on provisions for lease forfeiture or non-renewal. The deficiencies of this command and control approach have been widely recognised. They include the absence of any graduated system of response (Young and Wilcox 1984), the corresponding reluctance of administrative agencies to apply draconian penalties except in extreme circumstances, and a tendency towards preoccupation with other aspects of lease provisions (e.g. extent of development, or state of infrastructure) rather than land condition.

While the historical influence of these deficiencies can hardly be ignored, some have been addressed by amendments to pastoral land legislation in all states in recent years. Amendments in 2002 to the Western Lands Act in NSW, for example, provided additional flexibility for pastoralists to adjust stocking rate in relation to seasonal conditions (e.g. relaxation of agistment provisions), and provided a rental-based incentive to encourage conservation measures over parts of the lease.

Drought policy

Since 1992 the National Drought Policy (NDP) has stressed self reliance through the management of periodic rainfall deficits as a normal business risk, except in 'exceptional circumstances' when assistance from the public purse is justified. Part of this policy required the phasing out of transactional subsidies offered by State governments (e.g. freight subsidies for livestock or fodder) due to their perceived adverse environmental impacts, although this has not been universally achieved.

While the NDP has been a significant policy milestone, the operation of the joint Commonwealth-State arrangements for declaration of Exceptional Circumstances and the subsequent provision of financial support has not been straight forward. Botterill (2003) noted that the intent of the policy can often be thwarted by political realities, especially those associated with the pattern of Commonwealth and State elections. The declaration process has proved onerous, and uptake of the assistance available has often been low.

O'Meagher (2003) argued that few of the intervention measures applied under the NDP in the 1990s actually addressed clear instances of market failure. Most were argued to address symptoms rather than causes and some were even considered inconsistent with the overarching objectives of the policy. The continued use of interest rate and transactional subsidies was of particular concern from an economic perspective, although Condon (2002) considered that such measures have assisted the recovery of rangelands in western NSW since the 1950s.

While Exceptional Circumstances and other forms of drought relief have been the most prominent feature of drought policy in recent years, other integral components such as Farmbiz and its predecessor, the national Property Management Planning (PMP) campaign, have sought to foster self reliance through subsidised education and training activities. While the success of the PMP campaign varied considerably between regions, training opportunities through Farmbiz have been well subscribed. Together, these programs have probably made a worthwhile contribution to improved risk management across Australian agriculture.

Taxation

Condon (2002) considered that taxation concessions that encouraged the development of watering points and subdivisional fencing were second only to climate as a factor encouraging the recovery in western NSW referred to above, and in ensuring better resource management. To this extent, taxation policy could be argued to have provided a strategic basis for the reduction of environmental risk across the rangelands.

At the tactical level, however, the environmental benefits of current tax instruments are much more questionable. Stafford-Smith (2003), quoting Cross and Stafford-Smith (2001), noted that the common practice of deferring tax liability by use of low livestock valuations and drought-linked livestock sale elections discouraged early response to developing drought conditions, providing an incentive to achieve short-term financial benefits at the expense of long term planning. Increased environmental risk will be an inevitable consequence. These instruments thus reinforce the natural tendency for firms with high (or even normal) discount rates to prefer exploitative strategies, particularly in systems that are already operating below their productive potential and are characterised by long response times (Wang and Hacker 1997).

Income averaging, in Cross and Stafford-Smith's study, appeared to be relatively benign from an environmental perspective since it increased income variability as well as mean after-tax income and thus did not provide a means of reducing financial risk at the expense of environmental risk.

Other financial measures

Farm Management Deposits (FMD) have been well accepted by primary producers across Australia and will remain an important component of the policy environment. In the studies summarised in Stafford Smith (2003), they were thought to foster a closer relationship between financial decisions and natural resource implications than more direct taxation instruments, while providing a 'moderate' financial benefit. However, if redeemed for purchase of fodder, leading to the retention of stock on drought affected land, their potential for negative environmental impact may be greater than this study suggests, at least in those parts of the rangelands where this is a feasible option (D. Patton, *pers. comm.*).

No comprehensive assessment of the various drought-related financial measures that apply at the State level can be provided here. Taking NSW as an example, however, the Special Conservation Loans (SCL) scheme, which provides loans of up to $100,000 over 10 years at a fixed rate of 4.5% is the State's leading drought preparedness strategy, supporting a range of on-farm activities including planting of perennial pastures, and the development of fodder storage and water related infrastructure.

POLICY AND THE RANGELAND ENVIRONMENT

The common feature of the biophysical environment of all rangelands is the episodic nature of those events, particularly related to rainfall, that trigger changes in the so-called 'slow variables' that underpin ecosystem function. These include the processes that control nutrient cycling, soil loss, the spatial distribution of nutrients and water, and changes in the composition of perennial species. However, while major changes in these variables may occur episodically, at the extremes of the climatic spectrum, the response at these times is strongly conditioned by the management regime in the intervening periods (Watson *et al.* 1996). The risk of mortality of perennial grasses under drought conditions, for example, is closely related to pre-drought grazing history (Hodgkinson, 1995) and erosion under intense rainfall will be exacerbated where ground cover is reduced. Policies that minimise environmental risk should therefore not only foster a prompt response under deteriorating conditions but also a management regime in more 'normal' times that positions the system for the best possible outcome if environmental conditions move towards either end of the spectrum.

When social and economic dimensions are added to the biophysical, rangelands may be regarded as 'complex adaptive systems'. A characteristic of such systems appears to be that policies that restrict learning opportunities through regulatory approaches aimed at maintaining some desired system state ultimately lead to reduced economic performance compared to policies that allow learning and adaptation, even though the latter will result in initial resource degradation and economic hardship for some individuals. Balancing the need for learning with the need to prevent excessive resource degradation emerges as a challenge for policy makers (Walker and Janssen 2002).

Criteria for evaluating policy contributions to environmental risk management in rangelands might therefore include the extent to which policies:

a) stimulate early response to deteriorating seasonal conditions – drought responsiveness

b) encourage management at other times that positions the biophysical system for the best possible outcomes under more extreme conditions – resource conditioning
c) provide an incentive to avoid short-term profit taking to the long term detriment of the resource – discount compensation, and
d) ensure continuous learning and adaptation by pastoralists, by fostering a close relationship between financial decision making and environmental consequences – outcome focus.

While these criteria are not strictly independent they provide a useful starting point for the present purpose.

An assessment, in these terms, of the policies and measures outlined above is shown in Table 1, with particular reference to NSW. The overall impression is that while each of the criteria is satisfied by at least one measure, the current policy settings are not particularly well tuned to environmental risk management in the rangelands. This is particularly so given that participation in those measures with a favourable impact is far from universal, and that favourable impacts in relation to 'discount compensation' and 'outcome focus' arise only through the relatively weak provisions of the 2002 Western Lands Act amendments as they apply to rental determination. Although the measures summarised in Table 1 do undoubtedly contribute substantial public support to rangeland pastoralists in pursuit of legitimate objectives, the targeting of this assistance is not sufficiently precise to satisfy the criteria proposed here.

While this analysis is biased towards NSW it seems likely that the general conclusion would be more widely applicable.

Table 1. Assessment of the effectiveness of current policy measures in mitigating environmental risk, with particular reference to NSW. (✓– favourable impact; X – no impact or negative impact)

Policy regime	Assessment criteria			
	Drought responsiveness	Resource conditioning	Discount compensation	Outcome focus
Land Administration	X	X	✓	✓
Drought policy				
- Drought relief	X	X	X	X
- Education & training	✓ (?)	✓ (?)	X	X
Taxation	X	✓	X	X
Other financial measures (eg FMD, SCL)	✓ (?)	✓	X	X

AN ALTERNATIVE APPROACH

The analysis above suggests that policy initiatives should be investigated that satisfy particularly the criteria of 'outcome focus' and 'discount compensation'. This would focus public support directly on those desirable environmental outcomes that may be sought but are not guaranteed by existing policies. These initiatives will inevitably involve incentives and a move in this direction is already evident on a number of levels. Virtually all of the Catchment Blueprints accredited by the State and Commonwealth governments as vehicles for the delivery of public funding to natural resource management in NSW include provision for incentive payments in one form or other. A pilot program, the Environmental Services Scheme, is currently being implemented to purchase a range of environmental services from landholders, though predominantly outside the rangelands. Some other innovative programs, such as Bushtender in Victoria and the Liverpool Plains project in NSW, also reflect this outcome focus.

A program specific to the rangelands in NSW is the Enterprise Based Conservation component of the WEST 2000 Plus Rural Partnership Program. This pilot program is aimed at evaluating alternative approaches to the achievement of natural resource outcomes in the rangeland environment. Of particular interest in light of the discussion above is the 'ground cover option' which is currently being implemented on three of the 12 participating leases.

Pastoralists participating in the 'ground cover option' will receive a variable incentive related to their success in maintaining ground cover above a specified threshold. The general characteristics of this approach are summarised in Table 2. While a number of variations to this basic outline could be suggested, and may prove necessary, the measure in principle meets all of the criteria discussed in the preceding section. Drought responsiveness and resource conditioning are clearly encouraged. The increasing private cost of achieving public good outcomes (soil stability) as seasonal conditions deteriorate is recognised by a progressively increasing level of payment, consistent with the 'discount compensation' criterion. Finally, the 'outcome focus' criterion is met by the direct link between payment and on-ground results which simultaneously, since management in entirely unregulated, encourages learning and adaptation, and ensures that management actions, natural resource impact and financial consequences remain closely coupled.

The economic attractiveness of this proposal to landholders and governments remains an open question and has not yet been subject to detailed analysis. However, assistance to Western Division leaseholders in the current drought from all sources (State and Commonwealth) is expected to amount to approximately $59m, or more than $40,000 per lessee, by December 2004, after two years of drought exceptional circumstances (G. File, *pers. comm.*). Cost-neutral introduction of a ground cover based policy as an alternative to the current provisions might therefore require expenditure of a similar amount over a twenty year period, but with payments made over the eight years that would be expected below the 40^{th} percentile rather than the two years of EC declaration. While the maximum payment would not therefore be large (though still larger than what is likely through lease rental mechanisms) this arrangement would have the advantages of commencing much earlier in the drought cycle and avoiding the current difficulties associated with EC declaration. It should also promote more resilient pastoral businesses.

Table 2. Characteristics of the 'ground cover option' for incentive payments under the WEST 2000 Plus Enterprise Based Conservation program.

- Ground cover is measured at monitoring sites located by mutual agreement.
- Measurements are made annually in an agreed month (when cover is likely to be lowest).
- Seasonal conditions over the preceding year are based on a certified rainfall record and related to the historical record of an agreed base meteorological station.
- No incentive is payable if rainfall over the preceding 12 months exceeds the 40^{th} percentile.
- If rainfall is below the 40^{th} percentile, an incentive is paid that depends on
    - The rainfall percentile, with the potential payment increasing linearly to a maximum at or below the 5^{th} percentile.
    - The number of sites at which ground cover exceeds the threshold.
- Payment of the maximum incentive, regardless of groundcover, if stock numbers have been reduced below 10% of the average number over the last 5 years (to provide for the possible impact of feral animals or other factors despite management response).

CONCLUSIONS

Commentators on drought policy frequently make the point that there is no single correct solution and that a range of policy instruments is required. That position is not disputed here. What does seem apparent however, is that the policy settings and instruments so far developed do not entirely satisfy the criteria one might reasonably apply if the objective of those policies, even if only in part, is to reduce environmental risk.

A particular deficiency is the lack of policies or measures that provide appropriate incentives for management that conforms to the public interest under those conditions of rainfall deficit when the conflict with private interest is arguably greatest, directly relate support to natural resource outcomes, and actively encourage learning and adaptation by land managers.

Fortunately, there is much current interest in the evaluation of incentive-based measures that have the potential to satisfy these requirements and contribute to a policy mix more closely aligned with the realities of the rangeland environment.

REFERENCES

Botterill, L.C. (2003). Government responses to drought in Australia. In *Beyond Drought. People, Policy and Perspectives* (Eds Botterill, L.C. and Fisher, M.) CSIRO. pp 49-65.

Condon, D. (2002). Out of the West. A historical perspective of the Western Division of New South Wales. Octopus Production Pty Ltd. pp 381-2.

Hacker, R., Milham, N. and Patton, D. (2000). Policy implications of alternative models of pastoral decision making. *Centenary Symposium Proceedings*, Australian Rangeland Society, pp 127-32.

Hodgkinson, K.C. (1995). A model for perennial grass mortality under grazing. In *Rangelands in a Sustainable Biosphere. Proceedings of the V International Rangeland Congress.* (Ed. N.E West). 1:240-41.

O'Meagher, B. (2003). Economic aspects of drought and drought policy. In *Beyond Drought. People, Policy and Perspectives* (Eds Botterill, L.C. and Fisher, M.) CSIRO. pp 109-130.

Stafford Smith, M. (2003). Linking environments, decision-making and policy in handling climatic variability. In *Beyond Drought. People, Policy and Perspectives* (Eds Botterill, L.C. and Fisher, M.) CSIRO. pp 131-51.

Walker, B.H. and Janssen, M.A. (2002). Rangelands, pastoralists and governments: interlinked systems of people and nature. *Phil. Trans. R. Soc. Lond.* B 357: 719-725.

Young, M.D. and Wilcox, D.G. (1984). The design and use of quantitative monitoring systems for administration and management. In *Rangelands: A Resource Under Siege. Proceedings of the Second International Rangeland Congress.* (Eds Joss, P.J., Lynch, P.W. and Williams, O.B.). pp 513-15.

Wang, K.M. and Hacker, R.B. (1997). Sustainability of rangeland pastoralism – a case study from the West Australian arid zone using stochastic optimal control theory. *J. of Environmental Management* 50: 147-70.

Watson, I.W., Burnside, D.G. and Holm, A.McR. (1996). Event driven or continuous; which is the best model for managers? *The Rangeland Journal* 18: 351-69.

PROACTIVE RISK MANAGEMENT – THE SOUTH AUSTRALIAN APPROACH

Jim Cawthorne

Project Manager CNEFAP, Rural Solutions SA, 12 Tassie Street, Port Augusta SA 5700

INTRODUCTION

As every land manager knows risk takes many forms and is always present. Today, I want to talk about drought and the approach taken in the Central North East of South Australia to assist primary producers to cope with it. While this is the focus of my comments the principles can be applied to other risk events – it is just a matter of thinking it through.

SITUATION STATEMENT

The Central North East part of South Australia (see map Appendix 1) suffered several years of erratic rainfall, grasshoppers and locust plagues. This, coupled with low wool prices, had a devastating effect on the economy and the people of the area. It also had an impact on the natural resources of the area, which will take some time to recover.

Following a failed bid for Exceptional Circumstances (EC) support, a joint Australian and State Government package to assist producers to develop and implement strategies to increase their ability to manage risk was developed. This was the Central North East Farm Assistance Program (CNEFAP), which was officially launched on August 15th 2000 and closed on April 6th 2004. The Program, which had a high level of community involvement in its development and implementation, was about on-ground assistance to farmers facing hardship and industry adjustment. An important feature of CNEFAP was the involvement of the community in developing the structure of the Program and their insight to include a structured suite of projects, which would lead to lasting effects rather than short term financial relief for some. A formal evaluation has been compiled and some of the findings will be presented in this paper. During the time CNEFAP was operational the seasons were uncooperative to say the least: 2000 was very dry, 2001 was a very good year for those in cropping areas but for much of the rangelands was a continuation of the drought, 2002, 2003 and 2004 to date have been droughts. Stocking rates in the rangelands are down to one third of normal and have been for some time. Croppers have been living on savings and pool payments from 2001. Some have not sown a crop for two years and some of those that did wish they had not.

Not a pretty picture – and familiar to many in other parts of Australia over the last few years.

The question that challenges governments and industry on one front and producers on the other is how to manage the adverse event to survive and then recover as quickly as possible when favourable conditions return. I have deliberately posed the question in this way because it seems that it is often an "us and them" debate when, in reality, all parties are in the same boat. All need the primary industry to survive and be able to bounce back to normal as quickly as possible for economic, land management and social/infrastructure reasons. The current concern where national sheep flock numbers are much lower than normal is a good economic example.

This leads me to some of the other issues that have to be considered when developing an assistance package. There are many of them but in this paper I only want to mention four that I think have a huge influence on the overall outcome of assistance and recovery from an adverse event for primary producers – in this case drought.

ADDITIONAL CONSIDERATIONS

Before mentioning these, I am not an expert on design of drought packages. I do not have special qualifications in the areas to be discussed but I have been working as a Project Manager delivering assistance and reconstruction programs for the last nine years. The points that follow are personal opinions, in some cases supported by the views of policy makers, in other cases my opinion alone. But I would not mention them in this paper if I did not stand by them and believe them important.

a) Handled the wrong way assistance programs can encourage receivers to be dependent on assistance. In the worst scenario this means that people do not attempt to manage their risk believing that government will bail them out whenever they get into trouble. This is a recipe for disaster! Governments take time to act and in this scenario the people involved can be in very serious trouble before assistance arrives, if it arrives. It tends to increase the frequency of events needing assistance and fuels the severity of serious events. It also propagates a notion that people are not responsible for their actions.
b) On the other hand, to not provide assistance in times of severe hardship would result in a level of human, animal and environmental suffering that is unacceptable in this country. Accepting this, some assistance is needed from time to time. The timing, content and processes of the assistance are the critical considerations.
c) In this regard, it is important that the assistance measure(s) encourage people to take responsibility for their actions and to rely on their own resources – intellect, skills, finances, access to business support etc as far as is reasonable. In other words, to be self reliant as much as is reasonable. This introduces a problem. What is reasonable for one may not be for another. To manage this, norms, with a fair degree of tolerance, need to be established. Those of us who work closely with people usually have a fair idea of the norms for a particular group of people or industry. Accepting this, it is then possible to provide assistance that enhances the ability of people to be self reliant.
d) The fourth critical element is: - what needs to be provided immediately and what needs to come as follow up? Starving animals and serious human hardship cannot wait. These have a serious emotional effect on those responsible for the welfare of those suffering, i.e. the Owner/Manager and Partner. This cannot wait either. Recovery and rebuilding can wait a little while. Under current protocols, environmental degradation and economic hardship/losses are usually the focus of assistance packages. Unfortunately, the psychological and social effects do not get the same attention. These are difficult to assess and often seen to be invasive areas. However, the simple fact is that people under severe stress, suffering from anxiety, depression or both are not in a healthy state of mind to manage their way out of a crisis. They are either incapable of facing the real issues and thinking them through, make rash decisions or make no decision at all. The outcome in some cases can be one or more of the following: - declining health, domestic violence, self harm, and increasing severity of the impact of the drought / event on the business and people involved. The focus of assistance in this case should be to help people to manage "stress" so that they are in a good state of mind to manage their way out of financial trouble and address any environmental concerns.

THE CNEFAP EXPERIENCE

CNEFAP consisted of the following key elements:

a) Property Management Planning: - a small group workshop based process to encourage and lead producers through a strategic evaluation of their business. Producer attendance was funded by CNEFAP.
b) Individual business plans through a funded private consultant were available. Each business plan was funded to a limit of $3,000 – producers had the option of paying extra if they wanted a more detailed plan.

c) On the basis of an acceptable business plan producers could initially apply for a Productivity Improvement Grant ($10,000) and/or an Infrastructure Grant ($5,000), which would assist them to improve the productivity of their property. Later, a Drought Risk Management Grant ($5,000) was made available to assist the funding of drought risk management initiatives.
d) To support the above, an evaluation of likely diversification options (as identified by consultation with producers across the region) was prepared and the information made available to producers. The more popular options were the subject of supporting workshops. In all cases, printed information was prepared and made available at no cost. In several instances, workshops were held to assist industry bodies to review their strategic direction.
e) Producer-initiated R&D projects were also funded. This initiative allowed producers with innovative ideas to develop them further. A condition of grants provided was that the findings be made public so that others in the area could benefit.

These elements encouraged producers to become more involved in managing their way though drought at a time when they were getting worn down by stress and hardship. The program gave them some financial relief and enabled productivity improvement adjustments which would help them manage the drought and into the future.

It also acknowledged their plight (they were not over looked or forgotten) and gave them access to additional knowledge and skills, applicable to the situation facing them. It helped producers to see a way out of their predicament – to see positives rather than doom and gloom in an environment where confidence was being eroded and being positive was a real challenge. It did not provide measures that allowed them to borrow more money or provide access to funding that would keep them afloat without a sound business plan.

CNEFAP ACHIEVEMENTS

CNEFAP initiatives, the number of participants involved and the funds committed are summarised in Table 1. There were a total of 350 primary industry businesses in the program area.

Table 1. CNEFAP initiatives, the number of participants involved and the funds committed.

CNEFAP Initiative	Number	Total $
PMP	191 Participants	573K
Business Plans	147 plans	438K
Productivity Improvement Grants	109	1079K
Infrastructure Grants	108	534K
Drought Risk Management Grants	57	280K
R&D projects	10	367k
Enterprise evaluations	9	105K
Other Publications	5	50K

Table 2 shows project types undertaken, the expected benefits per project and the overall benefit per annum to the CNEFAP area. Table 3 shows participation and attitudinal data from two telephone surveys conducted by independent consultants.

As can be seen from the phone survey results (Table 3), 54% of participants in the survey thought that CNEFAP helped them cope with the drought.

It must be remembered that some were not eligible due to off farm investment, non viable, or non bona fide primary producer status.

It is also a fact that people initially just wanted the money and did not want to "jump through hoops to get it". They wanted help to survive – not training.

Figure 1, sourced from the October 2003 telephone survey, shows that while some may not have seen the value in the CNEFAP approach at the beginning, many found it extremely valuable during and after the event.

Figure 2, sourced from the October 2003 telephone survey, shows the CNEFAP activities perceived by Producers to be of the greatest assistance.

Table 2. Expected combined benefits from productivity, infrastructure and drought risk management grants approvals.

Project	Expected benefits per project p.a.
Alternative Power	$17,300
Cattle	$61,690
Feedlot	$180,070
Fencing	$326,050
Feral Goats	$31,850
Fine Wool	$404,530
Hay	$164,180
Land Development	$11,750
Lucerne	$1,070
Meat Sheep	$129,740
Minimum Tillage	$518,830
Piggery	$52,380
Saltbush	$74,000
Shearing Shed	$20,950
Tourism - Accommodation	$82,600
Tourism - Tours	$8,410
Water	$629,840
Grand Total	$2,715,240 p.a.

Table 3. Participation and attitudinal data from two telephone surveys conducted by independent consultants.

Telephone Survey of CNEFAP area. (50% of farmer/graziers in the CNEFAP area were contacted)		October 2001	October 2003
Awareness of CNEFAP		77.1%	86.9%
Participants in CNEFAP (any part)		42.9%	56.8%
Satisfied with service and application process	Participants only	89%	81%
Increased sustainable profitability	Participants only		81%
Beneficial effect on community	All surveyed		59.6%
More confidence as business owner/managers	Participants only		70%
Helped cope with drought	Participants only		54%
Positive outlook for the future	All surveyed		89%

In addition testimonials from producers recorded during the October 2003 telephone survey, indicate that the CNEFAP package was well received:

- "CNEFAP helped me look beyond the farm gate – to the processing end. It helped me to understand the kind of quality required for the export market and what we need to do to meet that demand."
- "Creating a business plan has helped us to focus on the strategic planning aspects of our business. It has helped us make informed decisions affecting our business and to monitor our progress."
- The CNEFAP program has been an incentive to look at continued productivity and sustainability into the future, whilst dealing with difficult and adverse seasonal conditions".
- "It was great to be able to try some positive options to diversify and spread the business risk – a light at the end of the tunnel during a period of adversity."
- "Applying for and receiving a CNEFAP grant helped us to improve the productivity of our business. Our feedlot has helped us maintain sheep numbers."

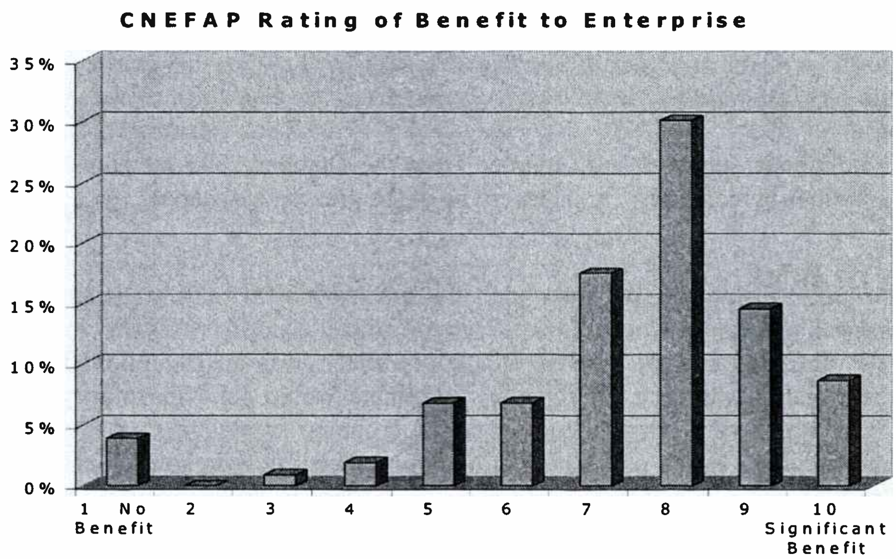


Figure 1. Telephone survey results sourced from October 2003 showing that while some may not have seen the value in the CNEFAP approach at the beginning, many found it extremely valuable during and after the event.

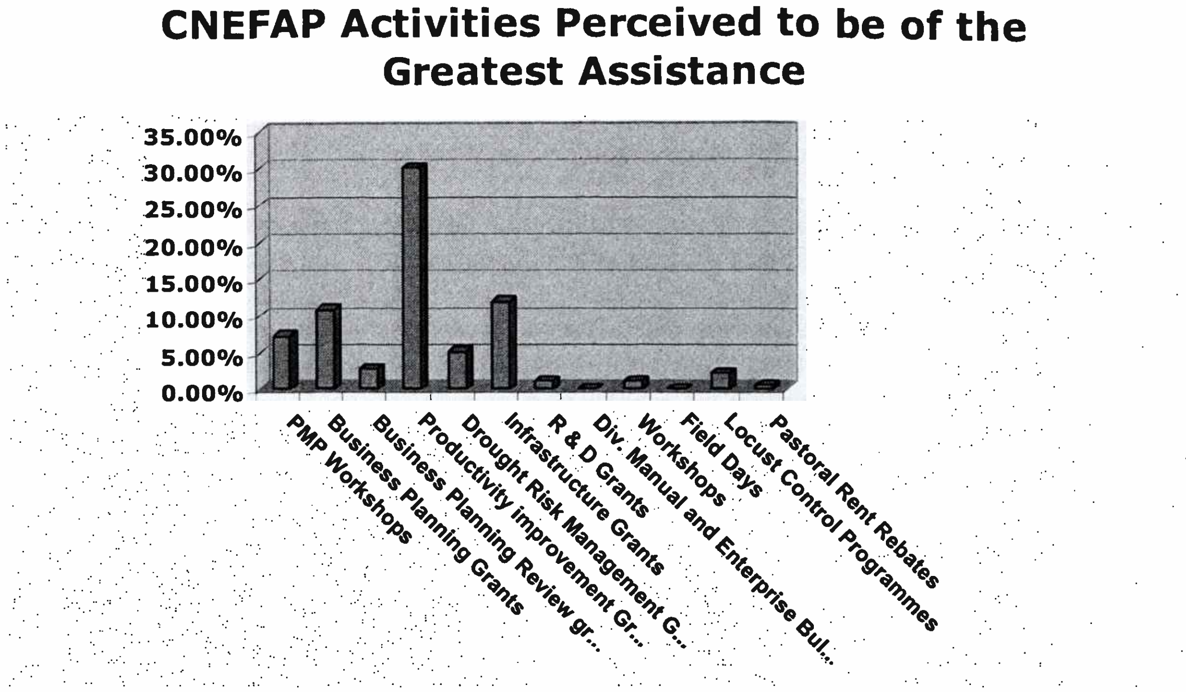


Figure 2. Telephone survey results sourced from the October 2003 telephone survey showing the CNEFAP activities perceived by Producers to be of the greatest assistance.

LESSONS LEARNT

As CNEFAP unfolded and we moved into 2001, which was an exceptionally good year for the croppers the situation was ripe for recovery. Farmers would have the money to adopt applicable change. There was a very positive outlook in the cropping areas, but short lived as 2002 and 2003 were severe droughts. In the rangelands drought continued, despite small local areas of relief. The area went further into survival mode. As a result, interest in diversification to spread risk and take advantage of more positive markets dropped away. Producers were focused on how to get their remaining stock through the bad times while at the same time minimising economic loss.

It was recognised that CNEFAP needed to flex to achieve its goals, i.e. help the producers through these difficult times with timely critical information while at the same time introduce planning skills and methods that matched their immediate needs. Some producers were not managing themselves, i.e. their stress levels, very well and the need for sensitively introduced awareness and information in this area was acknowledged.

In response to the situation workshops spread across the region were held. The core content of the workshops was drought feeding and stock management decision making. Added to this was a session delivered by an early-intervention mental health worker on stress management. The latter session was known to be essential but if offered on its own would not be attended by most males as it is not an accepted norm in rural communities for males to be seen at such functions. To some extent this is changing but admission of stress is largely seen as an admission of weakness. The workshops were low-key interactive sessions, set up so that all could share information rather than listen to a lecture. Workshops were well received. It was valuable for them to talk about their situation and find others were in the same boat. A feature of farmers' reaction to drought and related stress is that they stop talking, stop socialising and work to the point of exhaustion. A vital part of assisting recovery is to start them talking about their situation, sharing concerns and discussing ways of handling the situation. The sessions on drought feeding and stock management started this process and led into the stress management session.

The information provided on stress management was largely new to most. Feedback indicated that the stress management sessions were extremely valuable in terms of helping people to understand what was happening to them emotionally, the effects on their loved ones and what needed to be done. Some went on to seek professional help from stress counsellors.

As a follow-on to the road shows, the early-intervention stress counsellor, John Ashfield, wrote a book called "Taking care of yourself and your family" which was sponsored by the SA Government. This book is being distributed free of charge to producers in drought affected areas of SA and has been made available to the medical profession and support workers. To date over 3,500 books have been distributed. Feedback on the book is very positive.

While this was not part of the original agreement, it introduced a range of business management skills relevant to the situation and went a long way towards helping policy makers and producers understand the importance of personal management and the requirement for personal support in situations of adversity. It also alerted all involved that business management skills are only part of the solution to helping people manage their way out of adversity – the other part is the skill to manage themselves. Those of us who have been severely stressed know that it is difficult to make well-balanced and considered decisions when in this state. It is necessary to get yourself under control and then work on the decisions that need to be made.

CLOSING STATEMENTS

Proactive risk management is about developing the skills and knowledge to manage your way through adversity. We all know that adversity is a fact of life but most of us do very little to develop the skills to take it in our stride.

When things are going well most people want to reap the benefits and are not interested in skilling up to handle bad times. When things are bad the resources are often not there and the will has been eroded by worry.

Proactive risk management is about understanding this and making an extra effort while the resources are available and human capability is strong to organise the business, which includes the environmental, economic and people aspects in such a way that adversity is expected and strategies are in place to manage it so that the business comes out of hard times in good shape.

CNEFAP attempted to provide these skills. As it happened, the changing seasons and related changing circumstances of producers favoured interest in diversification and development of related business skills in the first two years. As the drought progressed they favoured decision-making related to survival and recovery. The added area of personal support was recognised and provided.

At the close of the program the area was still in drought, and while the businesses and people are still hurting, they are in better shape to recover when the drought breaks than before CNEFAP. They have new knowledge, skills and awareness. I expect significant further change will occur in the adoption of the new management practices, including climate and price risk management. Increased collaboration between primary producers will result in better management of natural resources and enhance productivity, profitability and sustainability of their businesses.

This will bring lasting benefits to the region and its people. The moral of the story is "give a family a fish and they will eat for a day, teach them <u>how</u> to fish and will eat every day". The key is teaching people <u>how</u> to manage, i.e. developing human capacity so that they have the knowledge and skills required to manage change and adversity.

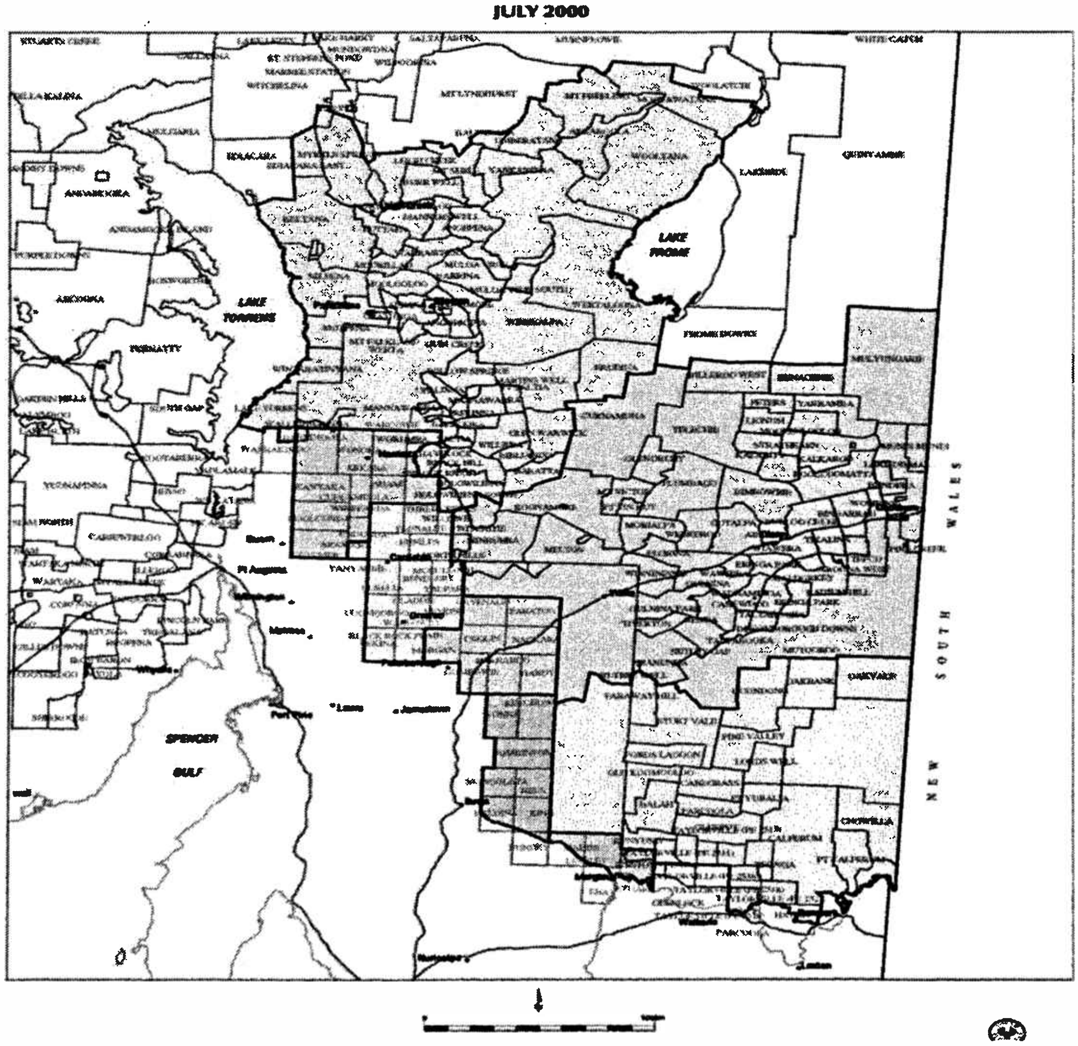
ACKNOWLEDGEMENTS

CNEFAP was funded by the Australian and SA Government and implemented through Primary Industries and Resources South Australia by Rural Solutions South Australia. In particular, I acknowledge:

- The vital role of the community in developing the proposed structure of the program and their insight to include the structured site of projects which would lead to lasting effects rather than just short term financial relief for some.
- The role of the PIRSA Agriculture Food and Fibre and Rural Finance and Development Divisions in managing the Program.
- The two telephone surveys commissioned by Primary Industries and Resources South Australia. These surveys were undertaken by the Lucas Group Pty Ltd of Norwood, South Australia.

APPENDIX 1

CENTRAL NORTH EAST FARM ASSISTANCE PROGRAM AREA
JULY 2000



HUMAN DRIVERS INFLUENCING CHANGE IN THE UPPER GASCOYNE AND MT MAGNET REGIONS OF WESTERN AUSTRALIA

Lynda Braddick

Institute Sustainability & Technology Policy, Murdoch University, South Street, Murdoch WA 6150

ABSTRACT

Major changes in production systems and land management in the Upper Gascoyne and Mt Magnet regions of Western Australia in recent years have been influenced by complex social, cultural, economic and political issues. These issues determine why leaseholders have implemented strategies for change or why they have not. In a recent interview process almost all leaseholders expressed difficulties in dealing with these issues and concern about the long-term sustainability of current or alternative industries. Current changes in animal production are creating conflict amongst some leaseholders and appear to be based on the continued degradation of the natural environment and reliance on markets in unstable, developing countries, raising questions about the long-term economic sustainability of these changes. This paper reports on the findings of interviews conducted in Mt Magnet and the Upper Gascoyne concerning factors influencing pastoralist's willingness and ability to change in response to their deteriorating circumstances.

INTRODUCTION

The townsite of Gascoyne Junction is 178 km east of Carnarvon and is around 905 km north of Perth Fig. 1). The town of Mt Magnet is in the Murchison-Goldfields region, 569 km north east of Perth, and 345 km east of Geraldton. The Upper Gascoyne has 28 stations with 20 leaseholders and Mt Magnet has 18 stations with 17 leaseholders.

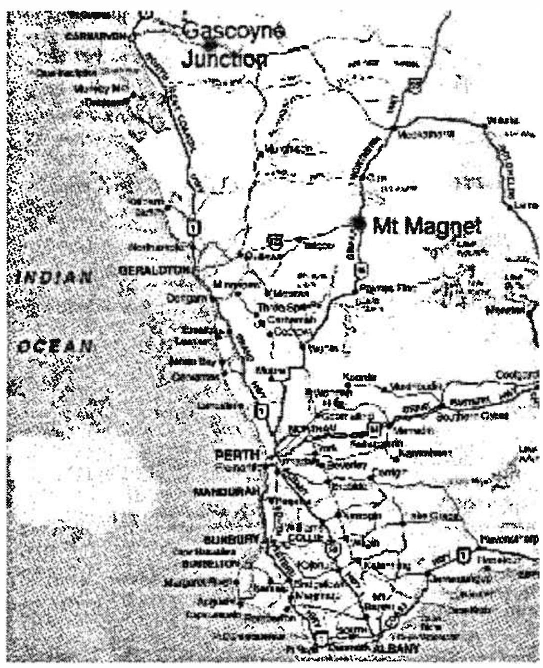


Figure 1. Location of Gascoyne Junction and Mt Magnet in relation to south west WA. (Source: Dept of Land Administration, Western Australian Government.)

Thirteen leaseholders were interviewed in the Gascoyne region, their stations totaling 3,622,331 ha and 12 leaseholders were interviewed in the Mt Magnet region, their stations totaling 1,112,923 ha (Pastoral Lands Board, 2003). The study included a wide diversity of leaseholders in regard to social and economic factors in these regions. One was an Aboriginal leaseholder on an Aboriginal owned station and much of this information was not pertinent to this discussion. These two regions are part of the Southern Rangelands which was opened up for pastoralism and grazing in the early 1800s (Morrisey, 1984). Two major factors influencing change have been alterations in world markets and the reduced production potential of the landscape caused by a combination of overgrazing and extreme climatic conditions (House 1991, McKeon 2000). Many leaseholders have changed the production base of their animals such as Droughtmaster or Braham cattle, Boer goats and Damara sheep. The management and/or sale of feral goats has also become an important component of income production for leaseholders. However the growing dependence on live exports of these animals to politically unstable Middle Eastern and Asian countries is a problem of emerging concern to leaseholders and other stakeholders within the industry (PGA 2004).

LEASEHOLDER ATTITUDE TO RISK

A large number of people from wide ranging disciplines have completed studies to determine factors that encourage the adoption and diffusion of innovations and land management practices (Vanclay 1992, Marsh *et al.* 1996, Cary 2002, Llewellyn *et al.* 2002, Flanery *et al.* 2003) and evidence shows that the decision maker's perception of risk is often considered to be the most important factor in the adoption of new technology. These risks include:

- consideration of the relative profitability of the new technology or practice,
- demographic factors such as age, gender, length of time they had leased or worked on stations, education, background experiences, accumulated wealth, dependent children and marital status,
- peer actions and community pressures,
- awareness and knowledge of the innovation,
- quality and quantity of station resources,
- environmental considerations, and
- attitudes toward risk. (Adapted from Marsh (1998) page 2.)

These factors have had varying degrees of influence on the ability and motivation of leaseholders to undertake change and their decisions regarding risk management. A pivotal factor in attitude toward risk exposed very clearly during the interview process was leaseholder reason for being there, whether they 'live to produce animals or produce animals to live'. As in other studies, leaseholders appeared motivated by the need to balance profit with a comfortable lifestyle which minimised risk (Cary and Barr 2000), but for some the lifestyle seemed more important. When asked what they enjoyed about being a pastoralist or grazier the majority of males indicated they liked the lifestyle or type of work while overall the females interviewed appeared less satisfied with their lifestyle. As a result the degree of uptake of innovative technology and management practices varied with their perceived view of income needs, risk perception, and dynastic and cultural expectations.

CHANGES IN PRODUCTION SYSTEMS

Different perceptions of risk management have resulted in some leaseholders choosing to remain with the same type of animal production while others have chosen to change or diversify the type of animal they produce. However it was difficult to gauge the difference between potential and real changes in production systems because of the current drought conditions and a number of leaseholders commented on their intention to change when conditions improve. Some leaseholders have chosen to improve the genetics of their animals in order to remain viable and/or spent extensive time and effort developing the production and management of their grazing system in order to maintain a reasonable standard of living. Leaseholders in the Upper Gascoyne have increased or changed their production to Droughtmaster or Braham type cattle within the last decade. One leaseholder in each region has developed a production system based on recently introduced animals from South Africa, the Damara sheep and/or Boer goats. The opportunity to learn about the production of these animals during an organized visit to South Africa by the Agricultural Department reduced many uncertainties and the need to trial and allowed leaseholders to make decisions to adopt or reject this change (Pannell 1999). Establishment costs of Boer goat production were reduced by using money from the sale of feral goats to set up trapyards to control and manage animals and fencing structures to train and contain increasing numbers of Boer goats. Goat production is perceived by leaseholders to have significantly less labour and costs than wool production because the work involved and vehicle expenses are less. For those leaseholders in the south-western region of the Upper Gascoyne where there are feral goats and in the Mt Magnet region, the sale of feral goats has been a vital component of their income during the last few years of drought. The downturn in wool prices and improved prices paid for feral goats by the live export trade have encouraged four of those interviewed to diversify into the management of feral goats and another leaseholder has sold all his Merino sheep and upgraded his infrastructure for the production of goats. A number of leaseholders in both regions suggested they may change to Damara sheep production in the near future. Leaseholders in the two regions are responding to the impacts of change in a variety of different ways. However the differing climate, erosional impacts of land use and the location of the two regions has resulted in significant differences in the decisions for change that have occurred.

Upper Gascoyne

Seventy per cent of leaseholders interviewed in the Upper Gascoyne have chosen to halt sheep production in favour of cattle in recent decades and those that remain in sheep are finding it increasingly difficult to sustain a viable wool production system. Cattle have always been part of the pastoral scene in this region however a number of developments have occurred in recent years that have changed the level of risks involved and encouraged leaseholders to sell their Merino sheep and change to cattle production. Low wool prices, mustering costs and a sizeable wild dog problem provided leaseholders in this region with few options other than a change to cattle production; factors commented on by leaseholders. Extensive overgrazing of this area in the past has also significantly reduced the production potential for sheep (Wilcox and McKinnon 1967). Mustering is necessary as water available in the river system makes trapping animals difficult. The timing of change seemed to be an important factor for the level of success of these new ventures. Those leaseholders who decided to change to cattle production early in the last decade appear to be coping better than those leaseholders who changed later as they were able to take advantage of the better seasons and cheaper cattle prices. The spread of buffel grass and the expansion of the live export trade provided wool producers in the Upper Gascoyne with a lucrative opportunity to change their animal production systems to cattle. Middle Eastern and Asian markets have a preference for breeds evolved under similar arid conditions and most leaseholders are now producing either Droughtmaster or Brahman. Braham (*Bos indicus*) cattle and their various crosses are more tolerant to heat, tropical pastures and ticks (Dalton and Bright 2003). Leaseholders consider that recent improvements in genetics and increased handling of cattle now provide a much quieter animal without horns that is easier to handle and also survives the ship voyage to overseas markets better than the traditional shorthorn breed, thereby reducing their risk of loss. Another trend that leaseholders consider is increasing the purchase of farms in southern regions such as Geraldton and Perth. Three leaseholders interviewed in this region have purchased farms in the Geraldton region. One well-established producer is supplying the Japanese long-grain fed cattle market and has retained part of his Shorthorn cattle production for this purpose. He is using his farm to fatten cattle from the station for this. Another leaseholder stated his station did not have the capacity to fatten cattle sufficiently for export so he had purchased a farm and now fattens bull calves or smaller cattle from the station and sells them to the domestic markets at Midland. The third leaseholder had recently purchased a station lease and was having problems with wild dogs getting their lambs. They bought a farm and intended to 'run 3000 head of ewes down there for fat lambs to get a cash flow'. They were then intending to buy cattle to stock their station. These leaseholders are choosing to live on the farms and have their children or relatives living on their stations. Consequently the demographics of the area are changing and altering the social cohesion within this community. This move may however provide a valuable solution to the problem of succession for those leaseholders who are able to afford to buy a farm. It also enhances their station production system, provides an opportunity for diversification and provides a valuable cash flow during times of drought. Some stations in the southern region are not suitable for producing cattle because of the different environment and one of these leaseholders has chosen to remain in Merino production and diversify into feral goat management. His problem of wool contamination by Damara sheep from stations nearby is reduced because adjacent government and Aboriginal owned land provides a buffer.

Mt Magnet

Leaseholders commented that the environment in the Mt Magnet region was not suitable for cattle production and they considered their choices for animal changes were limited to feral or Boer goats or Damara sheep. Some of those who have chosen to remain in sheep have changed to dual purpose Merino to spread their risks and one has chosen to improve the quality and supply a smaller niche market by producing stud animals as well as retaining a number of cattle. He is the only leaseholder in Mt Magnet with this animal mix and is considered by other leaseholders to be one of the most successful producers in this region. The remaining leaseholders in Merino production are using feral goats to diversify their income. One leaseholder researched the potential for feral goat management several years before the value of goats improved and has been able to take worthwhile advantage of these changing circumstances by selling all his sheep and establishing infrastructure for goat production. The younger age, innovative thinking, and a willingness to learn has enabled this entrepreneur to develop a financially productive system using an animal resource that was readily available and free. However, the sustainability of this type of production system is producing polarized views with some leaseholders arguing that the removal of the more destructive billy goat reduces environmental impacts while others consider that goats are more destructive to the perennial vegetation than other animals and see this as a problem for long-term sustainability of the rangelands. The leaseholder producing Damara sheep and Boer goats in this region has sold his Merino sheep because of the problem of wool contamination. This leaseholder was under 50, single, without dependents, independent, had alternative access to finance and appears to be an innovative thinker who enjoys learning about new ideas and technology. All these factors contributed to his adoption of an animal new to this region. However a small number of leaseholders have been affected by wool contamination due to his straying animals and this is resulting in increasing polarization within the community as leaseholders move toward a stance on continued wool production on one hand or a potential need to change to Damara production in the future on the other. Their reasons for considering change include: reduced potential income from wool in the future and the relative profitability of Damara, peer activities and a perception Damara protect themselves better against wild dog attacks. Factors influencing decisions to remain in Merino wool production were because leaseholders primarily identify themselves as wool producers and were just waiting for wool prices to recover, the cost of establishing new infrastructure, generational conflicts (see Rogers 2001), concern about Damara impacts on neighbours and community pressure. It is debatable whether attitudes toward the impact of different animal types on the land may have anything to do with leaseholder choice of animal production. However it was interesting to note that around 68% of leaseholders considered the animal they were producing had less impact on the land than other animals.

DIVERSIFICATION OPTIONS

The economics of change has a significant bearing on the ability of some leaseholders to diversify or change with around 70% of leaseholders stating that the financial downturn in wool prices made it difficult to implement change in their production systems. The difficulties of servicing current financial debts during drought conditions augmented this problem. Around 40% of households interviewed, including wives and children, had chosen to supplement their income from sources off the station. Only 20% of these were in the Upper Gascoyne region and the work involved labouring for other pastoralists in the region. One leaseholder has developed a large tourism industry on his property providing him with income to expand and improve his grazing system. Leaseholders in the Mt Magnet region chose to undertake a variety of off-station work including labouring for other pastoralists, developing alternative businesses based on personal skills, or living and working in urban centres using relatives to maintain the property. Two leaseholders were utilizing mining opportunities on their property. The differences in off-station work between the two areas may be explained by a number of different factors. They suggest there may be a real difference between the skill base of leaseholders in the areas, the influx of leaseholders relatively new to the region that have income gained from outside sources, the viability of stations that currently exists in these areas and/or the limitations for off-station income available for leaseholders because of distance from urban centres. Diversification into other options were thought to be limited by almost all leaseholders either because of environmental conditions, distance from markets, lack of infrastructure, regulations or lack of time and motivation. Tourism was the main option but was considered by almost all leaseholders to be only a small sideline and not viable as the principal income. However 24% of leaseholders have developed forms of tourism ranging from shearers quarters or homestead stays to organized educational groups and music festivals. One leaseholder is in the process of establishing horticulture crops to assist him to buy a herd and intends to produce crops for feedlot in the near future. Lack of suitable water sources and low returns for the work involved discourages other pastoralists from undertaking this type of diversification. It was also suggested the type of vegetables that could be grown is limited because of the difficulties of transport to market and that it was currently cheaper to buy fodder than to grow your own so they felt it was not worth doing.

OVERALL CHANGES

One of the major differences between the two regions is the changes in lease ownership and government land acquisition that has occurred in the Upper Gascoyne region within the last 2-3 decades compared to the relatively few changes in the Mt Magnet region. As a result of these lease changes, the number of leaseholders in this Upper Gascoyne region has decreased from 28 to 18 while leaseholders in the Mt Magnet region have decreased from 18 to 16. Changes in the Upper Gascoyne appear to be due to a number of factors including the sale of land for tourism or because of the lack of viability for pastoral purposes. The change to cattle generally required an expansion of land and this doubtless explains the number of leaseholder acquisitions and combining of leases in the region. These changes have contributed to a continuing decline of labour and services and a breakdown in the general cohesion of the Upper Gascoyne community, leading to questions about the sustainability of community life in this region (see MacGregor and Fenton 2000). This was strikingly evidenced by comments from Upper Gascoyne leaseholders about the breakdown of community activities and lack of assistance to newcomers in the region and the alternative comments from leaseholders in Mt Magnet concerning the positive community involvement in the Rangeland Fibre and Produce Group that has been established there.

The single most effective change for improvement of both grazing and environmental management systems has been the development and implementation of Total Grazing Management (TGM) yards to control feral goats and improve management of sheep and cattle. Around 64% of leaseholders commented they had improved or increased TGM yards in recent years and many who have not are on the river system which makes trapping difficult. Around 68% of leaseholders interviewed stated they accessed recent government funding to increase watering points, TGM yards and/or fencing on their property. TGM yards have the advantage of improving the number of animals mustered, reducing the costs of mustering and providing easy access to animals for husbandry practices (White 2002). It also assists environment management by providing potential to improve grazing management and increase efficiency of feral goat control. The percentage of leaseholders who accessed funding and increased TGM yards was similar in both areas suggesting the relative advantage of adopting this technology. Recent improvements in technology and the accessibility of government funding have aided the rapid adoption of this well-established infrastructure by leaseholders. It was affordable to most leaseholders, there was existing knowledge and established social practice with the use of this infrastructure and it had financial and time management benefits. This reduced the risks and complexity of developing the infrastructure and provided a strong advantage for adoption.

CONCLUSION

Overall, few major changes appeared to be effected before adverse financial conditions in the last decade forced changes in animal production systems and the adoption of genetic advances, new technology and improved land management techniques. The different changes in the type of animals produced are mostly a consequence of the differing environmental and predator conditions within the regions. Major changes that have occurred include:

- Change from production of animals originating in European countries to those from tropical countries to accommodate the changing export markets,
- Greater reliance on live export markets in politically unstable countries,
- Reduction in leaseholders within the Upper Gascoyne compared to the Mt Magnet region and the resulting impact on the availability of labour, services and the general cohesion of the community,
- Improvement in production system and land management due to increased installation of TGM yards, watering points and fencing, much of which was assisted by government funding.

Leaseholders willingness and ability to adopt changes was reliant on a wide variety of factors, however financial considerations were the overriding factors in adoption of change. Production is founded on volatile markets and erratic climatic conditions, increasing risks and making major changes more difficult. Many leaseholders in these regions have made significant changes in the last decade and have now established animal production system based on these highly unreliable factors and this has become a growing concern to leaseholders and other stakeholders alike. As favourable seasons return, this process of change will need to continue while global and environmental factors continue to place increasing pressures on these arid rangeland regions.

REFERENCES:

Cary, J. and Barr, N. (2000). Influencing Improved Natural Resource Management on Farms, www.affa.gov.au/content/publications.cfm, accessed 1/3/04.

Cary, J., Webb, T.J. and Barr, N.F. (2002). Understanding Landholders' Capacity to Change to Sustainable Practices. Insights about Practice Adoption and Social Capacity for Change. Bureau of Rural Sciences, Canberra.

Dalton W, and Bright F. (eds), (June 2003). Information on Pastoral Businesses in the Rangelands of Western Australia. Miscellaneous Publication 24/2003, Department of Agriculture, Western Australia.

Flanery F., Lovett A. and Hogan L. (2003). www.wool.com.au/awi/rwpattach.nsf/viewasattachmentPersonal/LW&WSurvey_200306.pdf/$file/LW&WSurvey_200306.pdf. Water & Wool Canberra and Australian Wool Innovation Ltd, Sydney, Australia

House M. (1991). Pastoral Region of Western Australia, Parliament Legislative Assembly, Select Committee into Land Conservation, Perth Western Australia.

Llewellyn, R., Lindner, R., Pannell, D. and Powles, S. (2002). Adoption of Herbicide Resistance Management Practices by Australian Grain Growers, SEA Working Paper 02/06, School of Agricultural and Resource Economics, University of Western Australia, Crawley, Australia.

MacGregor, C. and Fenton, M. (2000). Community Values Provide a Mechanism for Measuring Sustainability in Small Rural Communities in Northern Australia. *In* Country Matters. Conference Proceedings and Papers 2000, www.affa.gov.au, accessed 1/3/04.

Marsh S., Pannell D. and Lindner, R. (1996). Does Extension Pay? A Case Study of the Adoption of Lupins in Western Australia, SEA Working Paper 98/4, The University of Western Australia, Nedlands, Australia.

Marsh, S. (1998). What Can Agricultural Researchers Do to Encourage the Adoption of Sustainable Farming Systems, http://crcnet.vivid.global.net.au/newsletter/SeaNews/dpap987f.htm University of West Australia, accessed 29/3/04.

McKeon, G., Hall, W., Yet, J., Stone, G., Crimp, S., Peacock, A., Richards, R., Tynan R., Watson, I.

and Power, S. (2000). Learning From History: Land and Pasture Degradation Episodes in Australia's Rangelands, www.bom.gov.au/climate/cli2000/McKeon.html, accessed 16/4/03.

Morrisey, J. (1984). Arid Mulga Woodlands, *In* Management of Australian Rangelands. (Eds. Harrington, G., Wilson, A. and Young, M.). CSIRO. East Melbourne, Australia.

Pannell, D. (1999). Uncertainty and Adoption of Sustainable Farming Systems, http://crcnet.vivid.global.net.au/newsletter/SeaNews/dpap9901f.htm Agricultural and Resource Economics, The University of W.A., accessed 29/3/04.

PGA, Pastoralists and Graziers Association, (21st April 2004). Pastoralists Move on El Questro. Media Release, Western Australia.

Productivity Commission, (July 2002). *Pastoral Leases and Non-Pastoral Land Use*. Commission Research paper, AusInfo, Canberra.

Rogers, E. (2001). *Southern Rangeland Domesticated Goat Industry Tour Report*. Agriculture Department, Western Australia.

Vanclay, F. (1992). The Social Context of Farmers Adoption of Environmentally Sound Farming Practices. *In* Agriculture, Environment and Society, (Eds Lawrence, G., Vanclay, F. and Furze, B.), pp. 94-121.

Wilcox, D. and McKinnon, E. (1972). *A Report on the Condition of the Gascoyne Catchment*. Department of Agriculture Western Australia and Department of Lands and Surveys, Western Australia.

White K. (2002). *Total Grazing Management Yards*. Miscellaneous Publication 22/03, Department of Agriculture, Western Australia.

PEOPLE: THE MOST IMPORTANT ELEMENT FOR ENVIRONMENTAL INTEGRITY IN THE RANGELANDS

D. Lord

"Thackaringa", Broken Hill, NSW 2880

ABSTRACT

This paper looks at the trends of declining terms of trade and declining populations in the rangelands and the social, economic and environmental implications of those trends. It discusses the need for intelligent and relevant science to assist in slowing those trends. It strongly recommends to the Australian Government that it recognizes these trends and puts in place long term strategies to assist in ceasing them. It also calls on the Australian Government to recognize the valuable stewardship role that producers in the rangelands play in caring for the environment.

INTRODUCTION

My children are the 5th generation to live on "Thackaringa" which is a wool growing enterprise close to Broken Hill in western NSW. My expertise lies in wool production, unlike many of you who would be cattle producers. I am not qualified to talk on indigenous issues or health. However, I am qualified to talk on drought and, being a woolgrower, to talk on weak commodity prices over a significant period. I have had plenty first hand experience of both in the last 14 years!

We hear stories about bush kids who have never seen the sea, or the three year old from Tibooburra who bursts in to tears when a rain drop gets him on the brow, well Hugh turned 15 on 1/3/04 and saw green grass for the first time in his memory in October last year! So, reflecting on the past 14 years for this talk, the negatives easily came to mind. However, I also made a list of the positives and it is very clear that the positives far outweigh the negatives and that we have a great future.

I'm glad to be talking here today with people who are as keen as I am to ensure the survival of the rangelands as a productive landscape of huge importance to the Australian economy. Equally important, however, is the survival of the rangeland environment with its iconic beauty that is recognized world wide as being unique.

But I'm particularly keen to raise awareness about the impact of the negatives on the people who are the stewards of the rangelands. My feeling is that they require smart science, smart support and smart communications in order to cope better as families and as productive and sustainable businesses. We need to ensure there is continued support for those people who manage rangelands properties, so they remain in productive and viable, healthy communities and that these landscapes have the best of care well into the future.

Some of you would remember ten years ago at the Katherine Conference, when Bob Wynne delivered a paper entitled "Likely Survivors in the Wool Industry in the Australian Rangelands". Well most of us have survived this far. Three years ago my father, who will turn 80 this year said, "this is the toughest seven years we have ever had". Yet there have been very few properties change hands in this district over that period. That is pretty fair indication of the commitment that the people of the rangelands have.

The social well being of people in the rangelands, not surprisingly, is directly dependant on the economic situation at the time and on climatic conditions. As the cost-price squeeze tightens, the impacts of drought have an even greater social impact. One of the difficulties in considering social and economic risk in the rangelands is that not only are there a very diverse number of land systems / bioregions represented, but every family's situation is different. It would be a total waste of time in this or any other forum to discuss what I believe for example is the best way to market one's wool clip. What works for one operation may not suit another for a whole host of reasons. Also each person is the best one to judge their own situation, provided they have the tools to make the necessary decisions.

The greatest asset by far that the rangelands have, is the people who live there. We are not here for the easy or convenient living, we have made a choice to be here because it is our long-time home, we are an integral part of it and we (the rangelands and the people) are both reliant on each other for our well being and survival. I consider it a privilege to live in the rangelands and am totally committed to managing the environment for which I am responsible, in such away that it will continue to improve and return to (as near as possible) a pre-white settlement condition. My kids feel the same (even knowing the financial returns!), because it isn't just about those financial rewards. I think that my peers are of a similar opinion although they may not articulate it the same way. **The greatest threat** to the rangelands is the loss of people. Table 1 shows the national decline in people involved in agriculture since 1950 and the decline in net output value.

Table 1. Structure of Australian Farming 1950 -1990 from Godden, D. (1997).

	1951-52	1961-62	1971-72	1981-82	1991-92
Farms (' 000) (a)	203	202	188	174	124
Total area of farms (m ha)	441	475	500	491	466
Workforce (' 000) - total	477	453	407	380	374
– Employers / self employed			240	236	221
– unpaid family			23	12	23
– wage & salary			145	132	130
Female work force	31	42	42(b)		
Capital stock (excl. unimproved land value)	41,473	57,888	92,597	99,122	89,872
Output volume (1989-90 = 100)	35	52	74	85	97
Gross output value (87-88 = 100) (c)	80	85	90	100	85
Net output value (87-88 = 100) (c)	222	168	149	109	39

Sources: ABARE (1994), Powell and Milham (1990)

Notes: (a) several changes in the definition of "farm" from the mid- 1980s reduced farms counted, (b) 1970-71, (c) $ gross and net output value respectively, divided by Consumer Price Index

Figure 1 shows the steady decline in the price of wool since AD 1270 (source: G. Redden, Elders Limited, Adelaide).

"In 1950-51, the gross product of the farm sector was $1.83 billion which represented 26.1% of Australia's GDP, in 1990-91 that figure increased to $11.1 billion but agriculture's share of Australia's GDP declined to 2.9%" (Burdon 1996).

"In 1911, 43 per cent of the population lived in rural areas. This had fallen to 14% by 1976, before stabilizing in the past 25 years" (Beer *et al.* 2003).

This decline in population in the bush is a double edged sword. Not only is the work force depleted but social activity declines and the urban/rural gap widens. Subsequently, there is less empathy for the bush from within those urban areas.

"For much of the 20^{th} century there was a relatively even social and economic landscape in Australia. This was particularly true for the period between the end of WW2 and the mid 70s. There is a large and growing gap between the incomes of those Australians living in the capital cities and those living in the rest of Australia" (Beer *et al.* 2003).

It is therefore hard for many Australians to comprehend the serious cash flow problems experienced in the bush. There was a period in the 1800s when wool was a more valuable commodity than gold and the high wool prices of the 1950s wool boom is still in the minds of some who consider some of us to be "whingeing arrogant cockies". Well 50 years ago that may have been true in some cases; some of the TV programs and magazines currently available don't do our image a whole lot of good either.

If you look in the back of the document *Social Impacts of Drought* by Charles Sturt University – a report to NSW Agriculture and NSW Premier's Department, there is a long list of Commonwealth Government drought assistance measures. To the casual observer it would appear we are well catered for.

On looking at the annual reports from the Wentworth/Balranald Rural Counselling Service which formed in 1991, one can see that debt levels fluctuate somewhat. I quote from the 2001/2002 report that the average debt per farming enterprise on their books was $515,000 and average equity was 64.4%. These people are not bad operators; ten years of drought and low commodity prices are influences that they cannot control.

Some families made the decision to eat into their farm equity in order to educate their children. It is absolutely critical that children in the rangelands get a good education not only for their own well-being but also for the health of the rangelands.

The cost price squeeze will continue and the hard-nosed economic rationalists will say, "Get big or get out". I cannot support that theory broadly across the rangelands. There probably are some examples where an operation is too small, but we cannot afford to lose any more people. If for example, I buy out my neighbor, I have to run that new piece of country with a similar labor force as I have now. I then significantly increase our workload. The reality of it is that the opportunities for weed control, rabbit control, fox control, pig control are more limited. You might say that can be fixed with better management, but that's not the issue; a larger workload is the reality. It's not to say either that the big operators aren't responsible managers; they are in my experience. Different land systems require different management strategies, work forces, types of animals etc. **Bigger isn't necessarily better for the rangelands.**

SHOW US THE SCIENCE!

There is a dire need for relevant science in the rangelands, and the delivery of that has to be intelligent, regular and practical. My most vivid memory of the 1973/74 rainfall event was 'ill thrift' in sheep, particularly young sheep. I can remember the RLPB Ranger on his lice inspection at shearing time saying, that he "hadn't seen a decent mob of weaners anywhere in the district". I had suspicions of the cause, but without the science and despite my challenges to the hierarchy, I was reminded "you can't get worms in the Western Division".

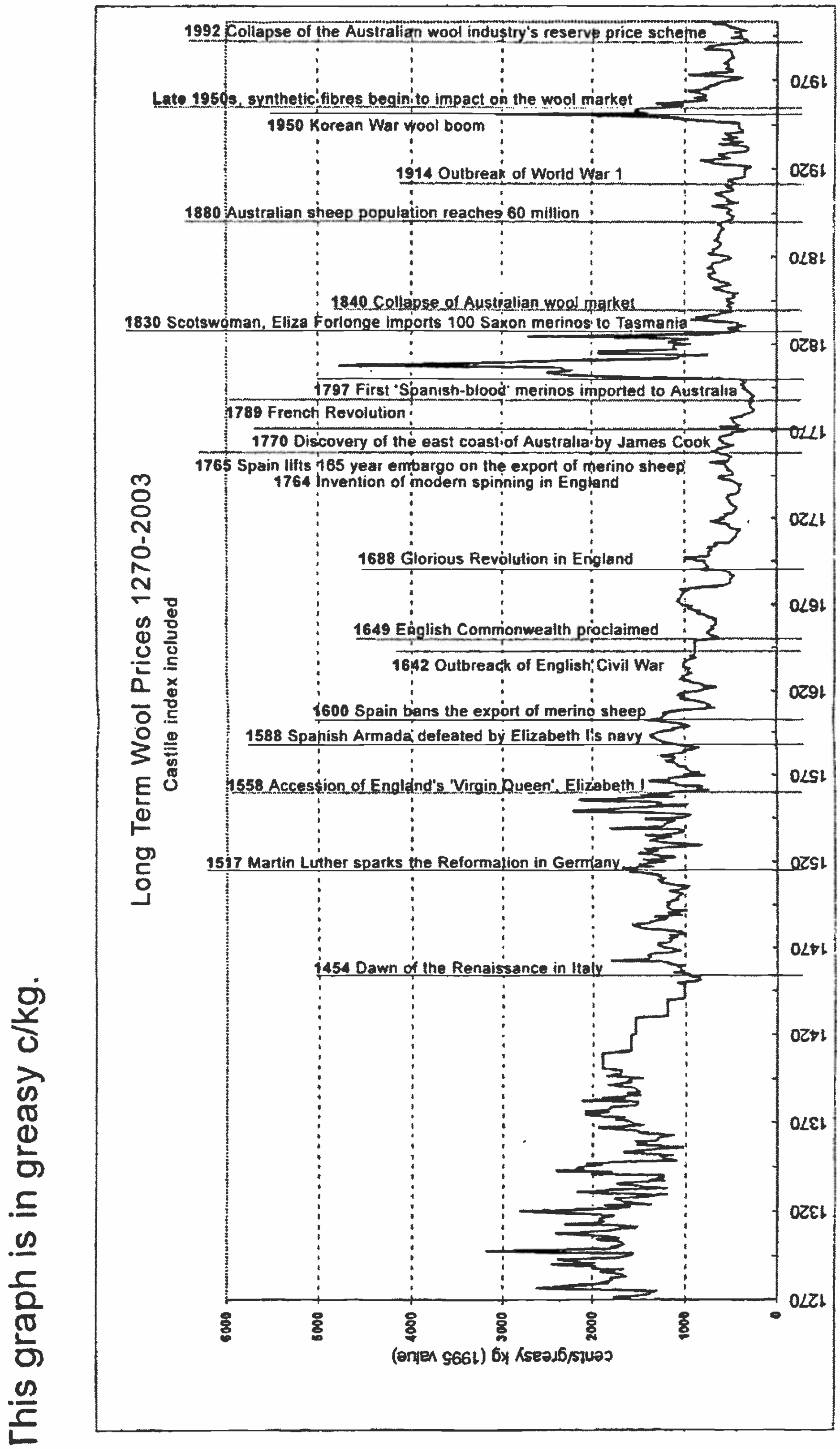


Figure 1. The steady decline in the price of wool since AD 1270. (Source: G. Redden, Elders Limited, Adelaide).

Well 30 years on not much has changed, except that in the last 15 years our flock has carried a very significant internal parasite burden three times that we know of. The last time it cost $50,000 in lost production before worms were identified as the cause of ill thrift, because it was considered to be "too dry to be worms". That $1.5 million in lost production over the 30-year period would be pretty handy right now! Approximately 9.5 million kg of wool go through the Adelaide Wool Stores each year, so assuming we were not special and that all wool producers have suffered similar losses, that equals $7.6 million in one year and $228 million in 30 years, based on the $0.80/kg loss we suffered in 2001. The government would have saved a fair bit of drought relief and other support measures if everybody had saved a proportionate amount of that lost production dollar and invested it wisely. The income tax received by the government would have more than covered the cost of putting some extension officers in the field to advise on these matters.

I tried for two years to obtain training on how to do faecal egg counts – to no avail. In desperation, I drove across the state and was shown how to by a friend, another producer. That was the most productive 2,400 kms I have ever driven. It is dead easy; I could show all of you before my 20 minutes are up, how to do it. One really has to seriously challenge the relevant Government authorities for not recognizing this problem and not assisting producers to learn how to recognize and deal with internal parasites. This is not the only state where this situation exists.

WEATHER PREDICTING – WE HAVEN'T GOT IT RIGHT YET

The area of weather predicting is relevant and very topical at the moment. There is a good deal of skepticism in the bush as to the accuracy of the predictions and I believe some of those arguments to be valid. However, short term weather predicting is pretty accurate, and a very valuable tool, particularly for producers in cold regions. I can also think of a producer in this region who looked at the weather on the Internet, saw that thunderstorms were imminent, shifted his sheep off the black ground to the red ground and saved potential losses of 3,000 head. While long term weather predicting may be useful for production forecasts on a national scale, it has all sorts of dangers for producers in the arid and semi-arid zone. We must never lose sight of the fact that it is **arid** and **semi-arid** and **unreliable** and manage accordingly.

I do think that the two departments who have been touting climate modeling viz. agriculture and meteorology have acted extremely irresponsibly over the last few years while the current drought has been upon us. Their prediction in September 2002 was that it would not rain until Christmas, then in January 2003 it would not break before April, well here we are in May 2004 and it still hasn't broken. So they got it terribly wrong and many people based their drought management strategy on those predictions. Not only did their fodder bills continue to increase, but on the whiff of a bit of rain 12 months ago, some began to restock – prematurely.

In January 2003 I rang the local ABC after hearing the current prediction and asked them to stop putting bad-news drought stories on air "before some one jumps off a windmill on a short rope". They are playing with people's emotions when they are already under extreme and long term pressure. I doubt that if I were offered an apology for their way of reporting (both the ABC and the departments from whom they sourced their stories), that I would accept it, as I believe their actions to be unacceptable.

THE RANGELANDS ARE SPECIAL AND NEED SPECIAL ATTENTION AND INDUSTRY/GOVERNMENT SUPPORT

What must never be overlooked is that agriculture in the arid and semi-arid zone is very different from agriculture in the higher rainfall cropping zones. We have to work **with** nature not against it and we must not try to push the system to beat the cost/price squeeze. There is a very real danger that the science applied to higher rainfall areas is extrapolated for our areas and is pushed upon us. An example of that followed the severe and sudden drop in wool prices in 1991, when there was a very strong push to encourage producers to reduce their micron to 19 or less. That push came from both the government and sectors within industry.

Fortunately, in this part of the country most producers resisted that push because they knew that "you can only produce what the country will allow" and that you have to have big framed sheep to handle the conditions when they are tough. The fine wool growers will tell you it is very difficult to grow fine wool and we know the discounts for vegetable fault etc. are high so you really need to balance these things up before doing anything too radical. I suspect that a lot of the finer-woolled rams have not survived the conditions. There are however some positives to the finer wool push which we in the rangelands can utilize.

In 2004 we are told we have to have big meaty merinos to accommodate the increasing demand for mutton, and the basis between the fine edge of the wool market and the medium is significantly narrower currently, so fine wool is less attractive price wise. However we do know that will fluctuate. You can't have both fine wool **and** big frame. This again highlights the need to take a long-term view and not be too sensitive to markets.

Producers need to balance all aspects before making changes to their produce. For example, the Australian sheep flock has fallen from a high of 180 million head in the early 1990s to less than half of that today. Consequently of course mutton is up, simply because of supply and demand. Also if producers in the higher rainfall zone shift to a finer flock then there is less of our type of wool on the market. This has proved to be the case – again, the supply and demand factor.

Certainly we in the rangelands can take advantage of agricultural research in the higher rainfall zone. For example, we can by buy better genetic material when we buy bulls or rams. Some of the advances in technology with respect to livestock, whilst aimed at the higher rainfall zone, also have relevance in the rangelands.

BACK TO CORE BUSINESS

For some reason there seems to be plenty of support for producers wishing to try out new commodities but little support for core business. This is very short-sighted when one reflects upon the number of new commodities that have gone by the wayside in the last 20 years. I can report that in 2002 the merinos did better than anything else on "Thackaringa", the red kangaroos left by July, those that stayed died, the eastern and western greys and euros nearly all died, the emus died, most of the goannas, the sleepy lizards, the crows and the goats died and we didn't see any wrens, chats or parrots for a year. Other people in the district made similar observations. If I need to run something other than merinos in the future to remain viable that is OK but whatever I do my produce must be quality. The key for me is living here and taking good care of "Thackaringa".

Not that I am opposed to someone having a go, and trying something else, but they have to be aware of the pitfalls and if they are to import an "exotic breed" (damaras) into a traditional wool growing area they also need to be aware of the potential for a class action against them for contaminating clips around them. Especially as we hear more negative feedback from our customers in relation to contamination of wool by foreign fibers. I can see a real issue developing here which has some very serious social ramifications.

WE NEED TO THINK AND ACT LONG TERM

This highlights the need for long-term thinking and actions. Producers in the rangelands do not have the ability to be as flexible as others in agriculture who may be able to switch readily from one commodity to another. We are limited in what commodities can be produced, i.e. we can't switch from wheat to fat lambs to barley to pigs at the whim of the markets. Most of us are specialist producers. We either produce all wool or all beef so if our market is down, gross receipts are down by the same percentage. If, however, you produce three or four commodities you would be unlucky for all to be down at the same time. Those outside the rangelands do not seem to recognize this. It needs to be understood by them that our needs are different and that we cannot deal with the cost/price squeeze by pushing the system. We have to be productive within the limits of the environment. Control of internal parasites is the classic example – it is very simple and relatively cheap to increase production if internal parasites are controlled.

Funding bodies seriously need to consider the value of long-term research projects – particularly in rangeland areas. It is only with such projects that the broad variation in climatic conditions – and the subsequent implications – can be captured. Short-term projects, while valuable in their own right, cannot possibly cover the range of conditions and the resulting unpredictable rangeland responses. For example, the lack of response in Mitchell grass in certain areas of Queensland this year (after very dry years followed by summer rain) may have been explained had there been a long term pasture research project set up in the most affected relevant area. In any case, at least the events leading up to the situation would have been recorded.

THREATS

Australia does **not** have a good record of proactive management by government of its natural resources. Luckily Australian land managers do though – the Landcare movement has demonstrated this – proactive communities, pushing the boundaries, asking the questions, doing the research and the tough work and asking the rest of the community and government to come along with them. They say government is not the leader and is only dealing with the common ground – it's so much more important that government listens and moves with the needs of the times.

Our inaction on rabbits is a classic; myxomatosis was discovered in 1896, and the Australian Government was alerted to the virus as a potential solution to the rabbit problem. It took until 1950 to get it released by a small team of scientists who were struggling for funding. Rabbit calicivirus disease appeared in China in 1986 and its release in Australia was under threat from funding being withdrawn – fortunately it escaped! Since then only a very few scientists have been able to do limited monitoring upon the virus and Dr Brian Cooke, Australia's leading rabbit researcher, has left to work in another country because he tired of short term funding cycles and the financial insecurity which that brought with it.

Since we completed ripping all the warrens on "Thackaringa" in March 2003 we have observed tracks of the endangered, and thought to be locally extinct, hopping mice (*Notomys*), not seen since 1860 when Burke and Wills moved through the area. From the initial sighting of tracks in December 2003, we now believe there must be thousands as the tracks are everywhere. Clearly, for the environment to recover, myxo and RCD on their own are not enough, a point which has been proven before. I hope by the time of this conference I will have had time to trap some of these animals and be able to report more specifically on them. Insufficient activity on control of cane toads and feral pigs is also of great concern to me.

EXOTIC DISEASE

I believe this to be one of the most serious threats to the rangelands. Unfortunately it is probably not a matter of **if** but **when** Australia experiences an outbreak of exotic disease. Should an outbreak occur it is highly likely that it will be devastating to the rangelands, economically, environmentally and socially and the impacts could be felt for decades.

While we have an Australian Government team to deal with the response to an outbreak, I don't see any proactive team with a plan to minimize the spread. As feral pigs are the most likely vectors for exotic disease, a plan to strategically "eradicate" feral pigs from significant areas of Australia would surely be worthwhile. This was attempted by The Lake Eyre Basin Coordinating Group but the Australian Government changed funding guidelines yet again, which severely restricts that community group from any on-ground actions in the immediate future. Their pig proposal initially met with some skepticism from a few who can now see the merit of such a proposal, especially since the current drought has done much of the work. It may be 50 years before we have such a broad scale drought again, so we missed a good opportunity. That doesn't mean that we cannot be successful with appropriate plans in the future.

SUPPORT

On reading the report by Queensland DPI on the FMD outbreak in England it was very clear that there was insufficient emotional support for **all** those involved. The conclusion in that report states "the impact of a FMD event on farm families and other families is significant and enduring. People experiencing post-traumatic stress are likely to need support and help over the medium to long term. Contingency planning must take into account that ongoing services will need to be provided long after the emergency has passed. Recovery of farm businesses may be a slow process for many farmers. It is essential that adequate services are available to help farmers during the recovery process." Dixon (2002).

With the current urban/rural gap in Australia I fear that lack of sensitivity and support would be duplicated here. I have felt that lack of sensitivity during recent times. During the current drought one extension officer said she appreciated that she could turn on a tap and have running water where those producers outside of town couldn't. Not everyone is as astute or thoughtful as that person.

INNOVATION

The people of the rangelands seem to have a thirst for knowledge and readily embrace new technology. Three developments that have contributed enormously to the well being of the rangelands are poly pipe, myxo and motor transport of livestock. They have been with us for 50 years now and I still see those developments having an impact. There is a plethora of new tools which we use that make us better and more efficient. For example, back line treatment for sheep and cattle, many with nil withholding period; email; GPS; poly tanks; UHF radios; electronic ear tags, important for national flock/herd health security status; Telstra's phone system; electronic scales; scanning devices; OFTA machine for measuring micron in the paddock; solar pumps; comfortable 4 wheel drives and motor bikes; digital cameras; new pumping technology; the list just goes on and on. All these things are enabling us to produce more without increasing stocking rate, in fact often we can reduce stocking rate, for example, by spreading waters.

We have educational organizations like Rangelands Australia, government run education seminars and some very good consultants running programs to help us be smarter. There are also tourism opportunities for some. The report on The Lake Eyre Basin Heritage Tourism Project is a very worthy document, as it is the first whole-of-basin, cross-border perspective on tourism and related natural resource management issues.

AUSTRALIAN GOVERNMENT POLICIES

I believe that Australian agriculture has a very bright future; we are well positioned geographically to access the high growth and populous markets of Asia as those countries develop. Our isolation should, if we are smart and vigilant, enable us to keep ourselves free of exotic disease. One of the real marketing advantages of the rangelands is our very limited use of chemicals and that our operations are sustainable so we can legitimately claim to be "Clean and Green".

There are a number of critical issues which we as exporters face:

- The exchange rate
- Interest rates
- Trade liberalisation, notably the Free Trade Agreement with the US and also changes to the EU.

The Australian Government needs to recognize the role of agriculture in the rangelands, not only in our contribution to the GDP but to our environmental contribution, when making policy.

FUTURE

I am very confident of the future but the Australian Government needs to recognize the trends and act now on these issues, not in 30 years when we may have really serious problems to contend with. Government needs to recognize the contribution that we give to the integrity of the rangelands – we have continuity of commitment, unlike short-term funding cycles. We have a vested interest in maintaining and improving the land. We need to be far more proactive in our approach to some of the problems like feral pigs, rabbits, cane toads, weeds etc.

Two of the great successes in Australia's history are the BTEC (Brucellosis and Tuberculosis Eradication Campaign) program and the Landcare movement. I think the BTEC program was a huge undertaking and an amazing success because of the commitment of those involved but it is also a great example of long-term thinking. That kind of thinking and strategy can be applied to other issues like feral pigs with equal success.

If I had been told in 1988 that I had 28,000 rabbit warrens and that I would have ripped all of them by 2003, I would have said that both statements were ridiculous. That achievement was only possible because of total commitment from those involved, in particular, my eldest children Emma and Charlie who took a year off between secondary school and university. Without their help it would not have happened in the time frame. Also financial support from the Australian Government meant that a 30-year plan was reduced to 15 years and with that a whole host of environmental benefits occurred that much sooner. So to say that feral pigs can be eliminated from vast areas of Australia, with the exception of some unique spots, is not an unrealistic goal, provided a long-term coordinated approach is taken and we use the naturally arid environment strategically to our advantage.

The rangelands are in good heart, the improvement in the last 50 years is just fantastic, and it just keeps on getting better as we deal with some of the issues, notably rabbits. Every year in spite of seasonal conditions, I see more plants, more animals, more cover, different species etc. It is clear that despite this drought being far longer and intense and financially crippling than possibly any other drought since white settlement, the country is much better covered that in previous "drys".

The Australian Government needs to get serious about some sort of reward system for land managers for their land stewardship efforts. I don't support a hand out system, but the US support wheat, cotton and rice to the tune of $4b pa (Financial Review, 28/4/04), obviously in US dollars and that figure is more than the value of the Australian wool clip, so clearly they recognize the need to support their farmers. I have over the last couple of years had some discussions about how this issue be approached. It is difficult, and there are plenty of reasons why a system would be unworkable but as an issue of national priority we need to sort through it and come up with some answers.

CONCLUSION

I'll continue to argue that it is crucial to have longer-term thinking and recognition that our communities really suffer under adverse conditions. I'll also argue that the people of the rangelands really are in the best position to care for the rangelands. However, they are going to need support if we are to have, and continue to have, viable and sustainable operations and vibrant and healthy ecosystems.

ACKNOWLEDGEMENTS

I would very sincerely like to thank the following people for their assistance with this paper; Brian Dodson and Merryl Kontogianis, Wentworth/Balranald Rural Counselling Service; Geoff Redden, Elders Limited; Rachael Williams, Charles Sturt University; Jenny Milson; Gerry Dixon, QDPI; Jenny Quealy and Mark Kleinschmidt.

REFERENCES

Beer, A., Maude, A. and Prichard, B. (2003). *Developing Australia's Regions: Theory and Practice.* UNSW Press, Sydney.

Burdon, A. (1996). Commonwealth Government Assistance for Adjustment in Agriculture Australian Rural Policy Papers 1990-95. Australian Government Publishing Service, Canberra.

Dixon, G. (2002). Foot and Mouth Disease. Ramifications for farm businesses and farm families. Lessons from England. Queensland Department of Primary Industries.

Financial Review 28/4/04.

Godden, D. (1997). *Agricultural and resource policy: principles and practice.* Oxford University Press, Oxford.

ENSURING EMPLOYMENT OPPORTUNITIES IN THE RANGELANDS OF AUSTRALIA

Carmel Wagstaff

Australian Agricultural Company, GPO Box 587, Brisbane Qld 4001

INTRODUCTION

A career in agriculture is a great choice for the right people. There are permanent positions and career opportunities in agriculture throughout Australia. Why then do we see people turning away from choosing a career in our industry? My belief is that our industry does not do itself justice. We do not market our employment well. We allow poor perceptions to cloud reality, e.g. poor wages. Work in rural and remote Australia is not portrayed to be the rewarding and professional employment it is. Many young people and their parents see employment on farms and stations in the rangelands as "the job you get before you get a real job". Continuation of these attitudes is a major risk to the survival of our rangeland industries and must be managed. We must attract the best and brightest into our industry connecting them with the right position, we must keep them in these positions and we must grow them further in these positions.

BACKGROUND:

I have lived in the rangelands on remote Australian cattle stations for 28 years from 1974 – 2002. My interest has always been the people who live and work on the properties, especially the extensive beef industry. I have seen a number of employees work and make careers in our industry or associated rural industries. I have seen many leave our industry. The reason for the latter is usually not lack of enjoying our industry work or lack of motivation, it is usually related to the 3 B's: bad boss, bad wages, bad conditions or perception of the above.

Over the past 28 years I have seen a steady drift away from young people seeking a career in rural Australia. Parents, career advisors and others tend to promote it as a bad choice. Many people in our industry talk our industry down giving a strong negative message. Good people are chased away by this negativity.

There are many employment and career opportunities for youth in rural Australia. They include:

- Production – animal and plant.
- Research.
- Sales – chemical, fertiliser, machinery, stock agents etc.
- Finance – banking, investment, insurance, accountants etc.
- Marketing – public relations, promotions etc.
- Services – veterinary, consultants, bookkeeping etc.
- Information technology – software development, e-commerce etc.
- Transport – mechanical, freight, trucking, shipping etc.
- Education and training – teachers, trainers, facilitators etc.
- Policy – agri-politics, economics, statistics etc.
- Media – journalists, producers, researchers, photographers etc.

We must actively work to change the perception across Australia that agriculture does not have good employment and career opportunities. We know we are professional business people running and working our operations. We have to be, to survive in our businesses.

We need to be more active in promoting our industry positively especially from within our industry if we are to attract future employees. Agriculture is a tremendous industry. But we won't have a viable industry unless we have people interested in working in it.

I will present four aspects of employment I believe the rural industry needs to work on in order to manage the risk of chronic staff shortages. These are:

a) Attracting new people to the industry, i.e. people who are not "born" into the industry,
b) Retaining staff by offering professional development and better management practices,
c) Taking a more professional approach to recruitment, selection and induction, AND
d) Recognizing the important (and economic value) of a safe workplace.

ATTRACTING NEW "OUTSIDER" EMPLOYEES TO THE INDUSTRY

There are three requirements here:

a) Accessible and impartial career and general information needs to be made more available and career opportunities vigorously promoted. It is essential to start in the primary schools because by the time young people reach secondary school, "attitudes" and poor perceptions are harder to change. Rural Skills Australia and the NFF have developed an interactive multimedia CD-ROM for secondary schools called "Ontrack". It is filled with information on today's exciting rural career opportunities including the beef cattle industry. It is rich with video content. The CD-ROM has gone out to over 5000 secondary schools across Australia.

b) We need to develop work experience opportunities for senior school students. Location should not be the reason it is not offered.

c) Employees need to have positive experiences. Good experiences from employees (i.e. "word of mouth") travels fast and encourages others to take up opportunities. We must all work hard to promote the positives from within our industry and not talk it down.

RETAINING OUR PEOPLE THROUGH PROFESSIONAL DEVELOPMENT AND BETTER STAFF MANAGEMENT PRACTICES

To attract people to future employment is essential, but far more important is to retain those already in our industry. To lose trained and efficient employees is very costly to any business. We as an industry need to put much more effort into retaining our existing workforce, training and developing them to be able to perform at their best all the time. As Peter Drucker said "The best way to predict the future is to create it". It is up to us.

The turnover of employees in rural industry and losing employees from the industry to other industries has been unacceptably high and very costly. The future of our industry relies heavily on our developed employees.

How do we retain our "developed" employees?

a) We can start by not taking them for granted and to do this we need to proactively engage the challenge of personal development of all within our industry. If we are to build on our business performance and productivity we have to be able to keep people interested in working in our industry and help people perform at their peak.

We have to teach our managers and middle managers how barriers to poor performance can be removed and it is their responsibility as managers to help people do the good job most want to do. There is a need to be good leaders if employees' output is to be maximised. To be good leaders, managers need to pay attention to their own professional and personal development.

b) Staff management is an area that needs to be improved across our industry. Outdated methods of handling employees needs improvement, recruitment and selection of employees need improvement. We need to put more effort into whom we employ and how we treat them as employees. There are many more options available today for potential employees. We have an educated workforce who has high expectations of their employment. They have rights and employers have a duty of care. They expect good communication from their employers. It is very difficult to keep motivated and do your best in a position if you are not sure what is required of you.

The simple basics of staff management

To develop career paths we need to keep our employees in our employ and ensure employees enjoy their employment. This will not happen unless we ensure our employees: know what to do, want to do it, know how to do it, have a chance to do it, and have effective leadership and guidance.

a) Know what to do.
Role clarity gives people something to focus on and strive towards. This encourages people to monitor their own performance and encourages individual accountability for performance and results.

b) Want to do it.
People will do a job only as well as they want to do it. The "want to" key has three aspects: job design, job placement and motivation. A good job has 3 E's:
  - enlargement (horizontal expansion),
  - enrichment (vertical expansion), and
  - empowerment (taking more responsibility).

c) Know how to do it.
If people know what to do and want to do it, can we set them to work? No, not unless they also know how to do the job.

People need to be properly trained in how to do the job and given time to build their skills and confidence.

This is building an enterprise through learning. Unless people skills are developed, maintained and extended the organisation cannot develop and prosper.

Training and continual learning is our investment in the future of our enterprise.

d) Have a chance to do it.
If a person knows what to do and how to do it and wants to do it, why do we sometimes get poor performance and low productivity? This is where giving people a chance to do their work comes in

We must ensure work method, systems and procedures and other mechanisms in the job environment contribute to assist productivity. Often they do the opposite – they get in the way of people doing a good job.

e) Have effective leadership and guidance.

Sound leadership sets clear goals and a good example provides the final touch to build performance and productivity. Even if all the other keys are in place, poor leadership can spoil it all.

Managers and middle managers need to practice what they preach, lead by example, coach, empower and help employees do their jobs well.

These are six characteristics of successful leaders.

- High self esteem.
- High standards.
- Challenging goals.
- Proactive.
- Focus.
- Good interpersonal skills.

RECRUITMENT, SELECTION AND THE CRITICAL FIRST DAYS OF EMPLOYMENT

As well as managing our employees better we need to recruit and select well. We can't afford to employ the wrong person, however the right person might not necessarily have all the skills needed for a position. We should be able to build on our employees. Rural workers by necessity are multi-skilled and need functional competencies. These can be developed through training.

Job descriptions assist us by improving our recruiting process and selection criteria assists with objective selection. Good interview processes have questions planned beforehand. Align the questions to cover selection criteria or headings of: e.g. General, Education, Work experience, Leadership qualifications, Communication and Application of knowledge.

Induct your employees well within the first day on the job. All efforts and time you have put into recruitment and selection can be wasted if new employees are not introduced to the workforce in an effective way.

Well planned selection procedures, sensitive induction, effective supervision and professional development of your employees can increase productivity, reduce staff turnover and increase the professional perception of our industry.

PROVIDING A SAFE WORKPLACE

We must also focus on workplace health and safety. Employers must ensure that every reasonable care has been taken to provide a safe and healthy work environment for their employees. This involves the establishment and enforcement of a proper system or method of work. It is a huge cost emotionally, physically and in monetary terms if we do not. Safety does not happen by itself – it has to be promoted constantly and consistently. Employers should set the example, by having good systems of work in place. The more safety conscious the employer is, the more safety conscious the work team will be. Accidents do not happen by themselves. All accidents are caused. At the root of every accident is a system of work, a machine or a piece of equipment failure. Do not risk danger to yourself or others by sloppy work practices. Safety is everyone's responsibility.

CONCLUSION

There are permanent employment positions in the rangelands of northern Australia. Many industry employers are concerned they have difficulty filling these positions. We must all work harder to positively promote our industry, marketing our jobs, our conditions and our wages better. We must lift the poor perceptions that dampen the enthusiasm of many young people to take up our employment. We must all work together.

People are our most important resource, yet can be one of our biggest overheads if not performing effectively and enthusiastically. Promoting a positive and rewarding work environment is essential. It is not enough to understand your markets and your products. In today's competitive world you need to understand your people if your business is to prosper. You will only succeed in business if you have the best people. The risk is we will not have an industry if we do not have people developing careers and enjoying the work we offer in our industry. We must continue to work on ensuring our industry is seen as the professional industry it is, offering rewarding careers to people.

I believe the rural industry needs to work much harder in attracting new people to the industry and retaining existing staff. We must take a more professional approach to recruitment, selection and induction and recognize the importance (and economic value) of a safe workplace. We must continue to offer professional development and implement better staff management practices. The future of our industry relies heavily on our appropriately skilled staff. If we do this we are managing the risk of the potential chronic shortage of skilled staff. If we do not, there will be increased costs to our businesses and we will not be able to arrest the exodus of skilled staff from our industry. This will seriously affect the long term social sustainability of the rangelands.

REFERENCE

Kris Cole (2001). *Supervision. The Theory and Practice of First – Line Management.* Pearson Education, Australia.

ECOLOGICAL AND ECONOMIC RENEWAL OF RANGELAND PRODUCTION SYSTEMS

T.H. McCosker, R.J. Bartle, and D.J. Carney

RCS, PO Box 633, Yeppoon, QLD 4703

ABSTRACT

One of the main challenges facing graziers is to manage their land in such a way as to achieve ecological renewal while at the same time maximising productivity of their livestock, looking after the people resource and maximizing the profitability of the business. This paper demonstrates that while possible, this is by no means easy.

Ecological renewal is a function of animal control and effective rangeland management. Both are capital and skill intensive. However the links between property development, improved livestock control and management, improved profitability and ecological renewal are quite strong. Ecological health and profits go hand in glove. Lowering margins on extensive properties will eventually force change in this direction and the innovators are already on this path.

AN OVERVIEW

Using data from the RCS benchmarking and business analysis software, ProfitProbe™, we firstly propose to provide an overview of key performance indicators in the rangelands. Firstly it is instructive to look at the Top 20% (T20) compared to the average (AV).

Table 1. The Percent Return on Assets (ROA) in three seasonal conditions from the Top 20% and Average Producers.

	N. Forest (Qld)			**N. Speargrass (Qld)**			**Coastal Forest (Qld)**		
	00-01	**01-02**	**02-03**	**00-01**	**01-02**	**02-03**	**00-01**	**01-02**	**02-03**
Season	good	avge	poor	good	avge	poor	good	avge	poor
AV	8.9	4.0	-0.3	8.0	2.6	-2.4	3.1	1.6	-2.4
T20	16.4	13.5	5.3	12.9	8.0	7.0	10.1	8.3	4.4
	Gascoyne Murchison (WA)			**NSW Rangelands**			**Mitchell Downs (Qld)**		
	00-01	**01-02**	**02-03**	**00-01**	**01-02**	**02-03**	**00-01**	**01-02**	**02-03**
Season	good	Poor		good	poor	bad	good	avge	poor
AV	11.7	3.7		6.5	0.1	-0.3	6.1	4.8	1.1
T20	23.0	14.6		26.1	9.8	6.3			

Table 1 illustrates several key points. Firstly there is a substantial difference between the two sets of data, with the T20 group being very profitable. Secondly, the T20 group made a profit even in the worst year, compared to losses for the AV group. Thirdly, the AV group was only as profitable in a good year as the T20 group in a poor or bad year. Fourthly, even average graziers can make reasonable profits when all the stars line up as they did uniquely in 00-01. Finally it illustrates how significantly rainfall effects profitability in the rangelands. This raises the question - "What causes the difference between the two groups?".

Figures 1 and 2 (following page) cast light on this question. Figure 1 illustrates the strong inverse relationship between ROA (%) and Cost of Production (CoP \$/kg LW) for Queensland Beef Producers in 2002-03. Each point (on the x axis of Figures 1 and 2), represent a producer and the data shows that those with the highest CoP have the lowest ROA and vice versa. Similarly the sheep data from the

WA rangelands in Figure 2 indicates that ROA is more a function of CoP than of price. Our data show that CoP is the largest driver of profitability in the grazing industries.

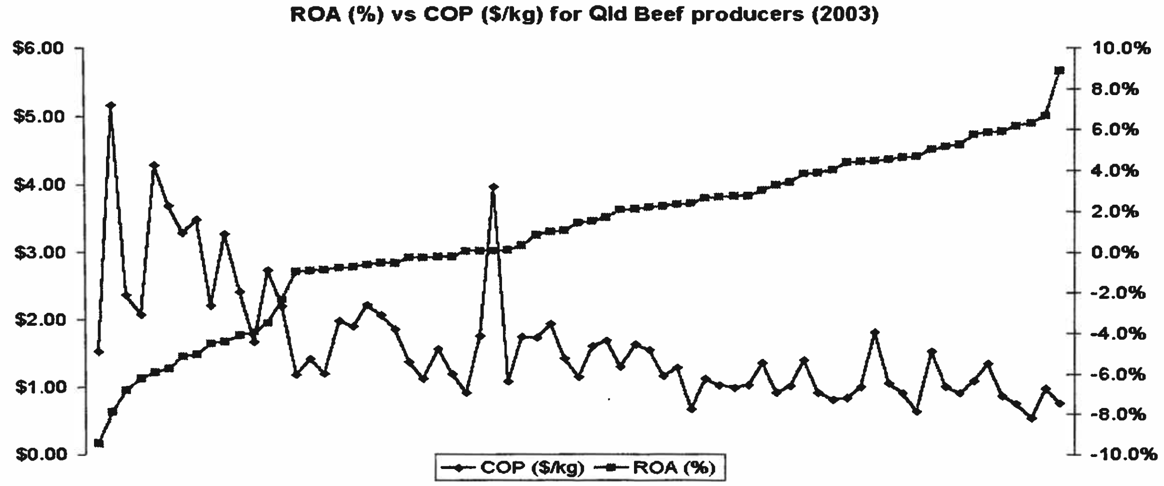


Figure 1. Percent Return on Assets (ROA%) versus Beef Cost of Production (CoP in $/kg LW) for 69 individual beef producers in Queensland in 2002-03.

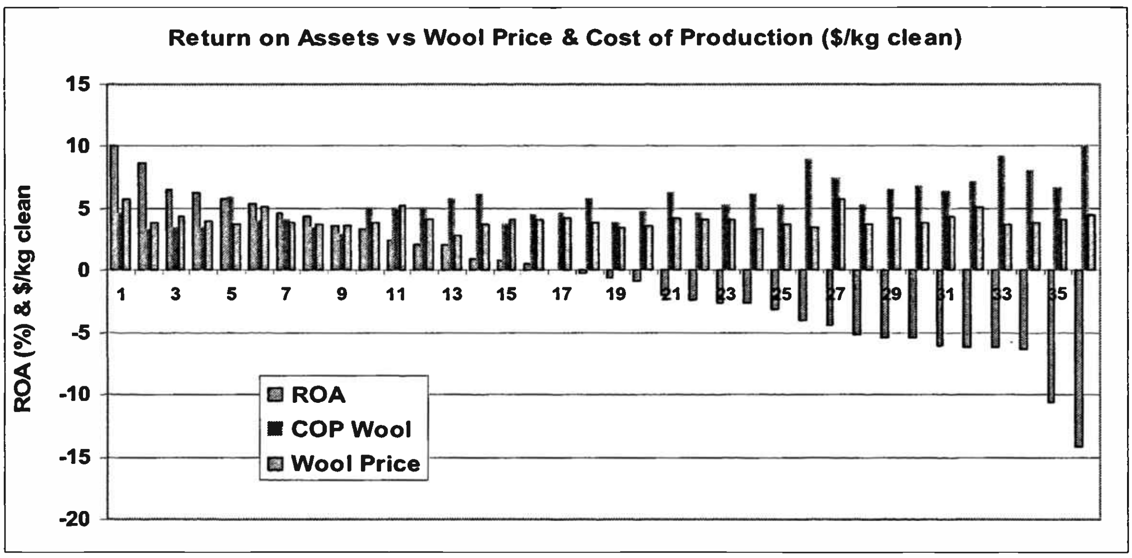


Figure 2. ROA, wool price and CoP in the Gascoyne Murchison region of WA for 36 individual sheep producers in 2001-02.

This raises a further question – "What drives Cost of Production?". Simply stated it is driven up by rising overheads and/or lower productivity, and is principally driven down through cost containment and productivity increases. A good leading indicator of CoP is Gross Product (GP) per Full Time Equivalent Employee (FTE) and this is illustrated below in Table 2. A positive number indicates the T20 group has a higher Gross Product (a measure of economic output) per FTE. It is clear that the gap starts to get bigger in 1994-95 and 1995-96. These are the years during which we realized the driving nature of this indicator on profitability and developed strategies to lower CoP and increase GP/FTE.

Gross Product per FTE is driven by price, productivity (meat and wool production per ha and per head) and the ability of management to achieve productivity gains while containing overheads.

CASE STUDIES

We have selected several clients of RCS in the western Queensland rangelands, who have made changes and whose data we have over an extended period, to look at what happens when property development and management change with a focus on balancing ecological renewal, production and profitability. The property development included water development and fencing which facilitated pasture resting, better utilization, more accurate attempts at matching stocking rate (SR) to carrying capacity (CC) and more planning and monitoring of grazing.

Table 2. The difference in GP/FTE ($000) between the Top 20% and Average producers in the Qld, NSW and WA rangelands.

	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03
GP/FTE	30	30	26	49	63	99	65	56	89	155	91	124
						Gascoyne Murchison >			52	55	31	

"Somerville", North of Richmond in North Queensland

"Somerville" is a 29,000 ha cattle property owned by Tony and Mandy Mott with approximately one third each of sandy open forest, Gidyea country and black-soil downs. AAR is 458mm. It had been run on traditional lines until 1993, after which the waterpoint density were improved to no more than a two km grazing radius and the property was fenced to facilitate both cell grazing and rotational grazing systems. This was largely completed by 1997. The numbers shown in Table 3 are frequency of occurrence, totaled for the plant grouping and averaged across ten sites. Sites were chosen originally on healthy rangeland, some distance from original and new water points.

Table 3. Summary of ten GrassCheck sites on "Somerville".

	95	**96**	**97**	**98**	**99**	**00**	**01**	**03**
Ground cover > 50%	29	11	27	31	27	17	23	12
Desirable perennial grasses	60	50	54	34	54	51	49	46
Undesirable perennial grasses	23	24	25	31	22	22	23	14
Annual grasses	119	69	115	91	77	68	59	97
Forbs	0	12	13	4	14	22	61	121
Rainfall (mm for wet season)	410	306	625	432	573	771	913	287

Rainfall in 2002 was 367 mm but the Grasscheck sites were not monitored.

The only trend evident from these data is the increase in forbs since 1999, despite an increase in carrying capacity and stocking rate. This occurred in both frequency and number of species recorded. Despite a considerable amount of effort expended by the Mott family and staff on monitoring, the Grasscheck process did not provide them with any useful feedback on their management practices. We have found that it is too subjective, influenced by recent grazing pressure and difficult to interpret.

"Wolston" and "Lilford", South of Richmond in North Queensland

"Wolston" and "Lilford" is a 36,000 ha aggregation owned by John and Claudia Power in open Mitchell grass downs, running sheep and cattle. Annual average rainfall is 450 mm. It had been run traditionally until 1999, after which the waters were improved to a maximum 1.5 km grazing radius and fencing was started on the 16,000 ha at "Lilford" to facilitate rotational grazing. Paddock numbers were increased from 6 to 14. Property development is continuing on "Wolston".

The data (Table 4) for these two stations are instructive as they show:

- ROA in the good years following property development (1999 to 2001) was much higher than that of the earlier good year (1994-95).
- That the variability in production and profitability over an extended period is large.
- An effective trend in reducing both wool and beef cost of production and how beef CoP rose sharply in a low production year (eg. 2001-02).

Table 4. Data on "Wolston" and "Lilford".

	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02
Stocking Rate (SDH/100mm)[1]	9.7	14.4	7.4	11.6	9.4	8.4	12.9	18.2
Carrying Capacity (SDH/100mm)	8	8	8	8	8	10	12	12
Rainfall (mm)	496	303	482	397	522	713	515	276
Seasonal Description	good	poor	good	average	good	good	good	average
ROA (%)	3.1	0.4	0.8	4.7	5.2	7.2	8.1	4.3
Beef CoP ($/kg LW)	0.70	1.07	0.97	0.67	0.46	0.41	0.40	0.95
Beef Prod'n (kg/ha)	12.6	8.5	8.5	11.3	19.6	18.3	28.7	14.4
Beef Prod'n (kg/LSU)	109	94	81	87	115	131	138	96
Wool CoP ($/kg greasy)	5.57	5.60	5.84	3.44	3.85	3.84	4.98	4.67
Wool Prod'n (kg/DSE clean)	2.4	2.4	2.2	2.4	2.6	2.9	2.7	3.2

[1] SDH/100mm is Standard Animal Unit days grazing per hectare per 100mm rainfall.

"Wybenia", North West of Winton in North Queensland

"Wybenia" is an 8,700 ha property acquired in 1997 by Doug and Fiona Nicholson in open Mitchell grass downs, running principally sheep with cattle as a sideline. AAR is 400 mm. It had been run traditionally until Jan 2001, after which the waters were improved to a maximum 1.5 km grazing radius and fencing was completed in mid 2002 to facilitate rotational grazing.

Table 5. Data on "Wybenia".

	97-98	98-99	99-00	00-01	01-02	02-03
Stocking Rate (SDH/100mm)	19.4	5.1	6.3	21.5	19.2	9.1
Estimated Carrying Capacity (SDH/100mm)	6.0	6.0	6.0	6.0	8.0	10.0
Rainfall (mm) AAR = 400mm	635	427	782	279	229	337
Seasonal Description	good	good	good	average	poor	average
ROA (%)	2.3	-1.7	0.0	12.3	3.6	3.7
Beef Cost of Prod'n ($/kg LW)	0.67	0.78	0.49	1.99	1.33	1.59
Beef Production (kg/ha)	36	11	21	31	20	8
Beef Production (kg/LSU)	108	143	196	41	95	92
Wool COP ($/kg greasy)	na	6.20	4.32	3.62	4.49	9.07
Wool Prod'n (Kg/DSE clean)	na	3.60	2.87	4.16	2.60	2.00

The ROA was poor from 1997 to 2000, despite good years. An average year, 2000-01, had the highest ROA due principally to an excellent trade with cattle, which also explains the very low production per LSU. It also had a good sheep trade which produced the anomalous wool production figure (kg/DSE).

Stocking rate (SR) exceeded carrying capacity (CC) in three of the six years with the effect of overstocking in 2000-01 and 2001-02, carrying over to 2002-03 in terms of animal performance, despite getting the stocking rate right in 2002-03. SR exceeded CC in 2001 due to inexperience in feed budgeting. The effect of this one bad decision was still affecting the property in 2004. Animal performance (kg beef/LSU and kg wool/DSE) was highest when SR matched CC.

Basal area of Mitchell grass plants from five fixed transects is averaged in Table 6. Rainfall is for the 12 month period to the end of May (mm) averaged over the same five sites. Flinders grass, herbage and feather top were also recorded, although there were limited amounts of each.

Table 6. Basal area of Mitchell grass on "Wybenia".

	June 24th, 2001	May 8th, 2002	April 29th, 2003	April 22nd, 2004
% basal area of Mitchell plants	8.6	13.9	8.1	4.5
12 months rainfall (mm) to May	337	229	304	237

In each season, the bulk of the remainder was bare ground but there was 9% feather top at one site for the first two years but this had gone in the last two years. Both herbage and Flinders grass were only occasionally present and only in very small amounts. In the first two years, the SR exceeded the CC by a factor of two, but the Mitchell remained in good condition largely due to a good wet season in 2001. However in the subsequent two years of very low rainfall, the Mitchell grass regressed severely, despite the SR being matched to CC. Very light grazes were made in association with long rest periods in the latter two years, indicating the Mitchell grass was more severely affected by the rainfall distribution, than by grazing management.

"Yuruga", South West of Longreach in North Queensland

"Yuruga" is a 12,000 ha property owned by Cam and Jenny Lindsay in open Mitchell grass downs, running cattle. AAR is 390 mm. It had been continuously grazed until mid 1999, after which the waters were improved to a maximum 1.5 km grazing radius and fencing was started to facilitate rotational grazing and cell grazing systems. This development was largely completed by the end of 2002.

Table 7. Data on "Yuruga".

	98-99	99-00	00-01	01-02	02-03
Stocking Rate (SDH/100mm)	7.3	15	19.6	14.8	18.9
Carrying Capacity (SDH/100mm)	12	12	24	18	18
Rainfall (mm)	813	473	303	352	228
Seasonal Description	v. good	good	average	average	poor
ROA (%)	9.0	Na	17.7	9.7	1.1
Beef Cost of Production ($/kg LW)	$0.46	Na	$0.31	$0.58	$1.43
Beef Production (kg/ha)	19.5	Na	22.7	22.1	9.3
Beef Production (kg/LSU)	119	Na	139	155	79

The data in Table 7 indicate that:

- In the first very good year (1998-99), prior to any property development and management changes, cost of production was similar and production per head and ROA were lower than in an average year following property development (2001-02).
- In 2000-01 and 2001-02, SR was below CC and animal performance was high.

- In 2002-03, SR slightly exceeded CC and production per head was low. A very short season and destocking would also have influenced these results.
- The carrying capacity benchmark was lowered in 2001-02 as more time elapsed following the good seasons.

The trends in basal area of Mitchell grass plants from 2002 to 2004 are identical to those on "Wybenia" (Table 8). Most of the grazing yield in the last two years came from herbage rather than Mitchell grass. This decline in Mitchell grass basal area also occurred despite very light grazing and long rest for the pasture, confirming that the decline is associated with the environment rather than the management.

Table 8. Basal area of Mitchell grass on "Yuruga".

	Feb, 2002	**April, 2003**	**April 22nd, 2004**
Basal Area of Mitchell Plants	14%	na	5%
12 months Rainfall (mm)	208	125	185
Days Grazed in a year	216	22	30
Number of grazes	2	3	2
Yield (Stock days per ha)	65	51	16

"Kariegasfontein", Aberdeen, South Africa

"Kariegasfontein" is a 12,000 ha property owned by Norman and Jenni Kroon in the Karoo region of South Africa. It receives 195 mm AAR and supports sheep, goats and cattle and is managed by Phillip McNaughton, who has supplied the data. It had been run in a cell grazing system since 1973, with a maximum 2 km grazing radius. Property development has facilitated more appropriate utilization of pastures, allowed pastures to be rested, and facilitated better control of livestock in a rangeland situation.

The purpose of including "Kariegasfontein" is because of the unique data on the relationship between feed available and wool production and reproduction rate, on a commercial scale. The methodology used was to compare the average wool cut per head and the lambing rate to the ratio of the budgeted feed available (in large stock unit (LSU) days) between 1997 and 2001 (the Carrying Capacity) and the actual feed removed (the Stocking Rate in LSU days as recorded on a grazing chart). The seasons run from wool clip to wool clip. A negative number means the stock were eating into the feed reserves being kept for ecosystem health, and the SR thus exceeded what was considered to be an ecologically healthy CC.

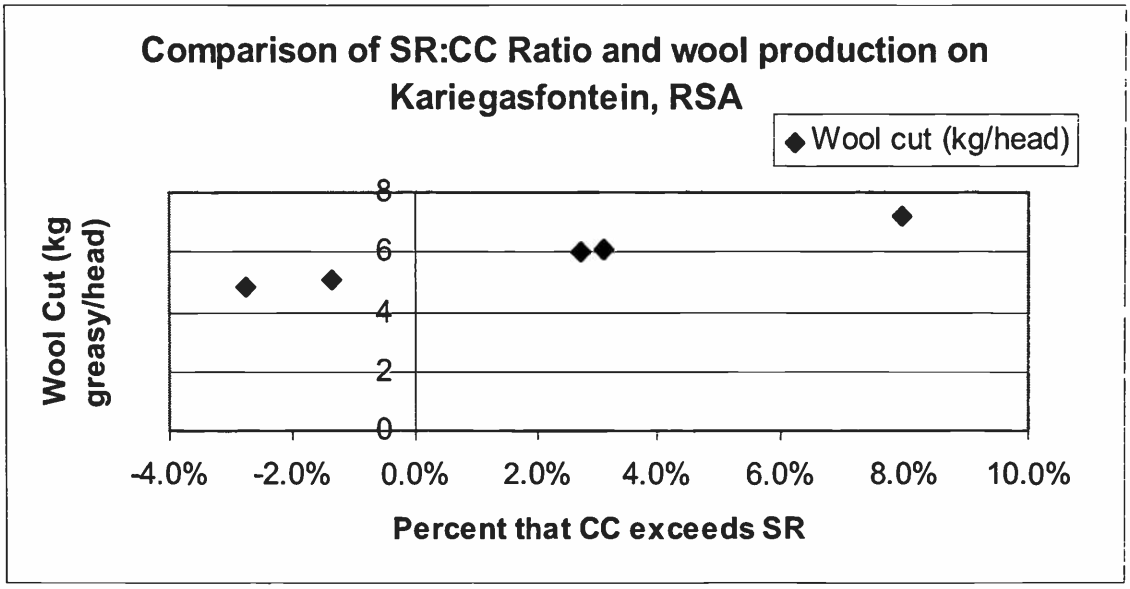


Figure 3. The relationship between wool production per head and the percent by which estimated carrying capacity (CC) exceeds actual stocking rate (SR).

The data in Figure 3 show that even very small variations between SR and CC have significantly affected the wool cut per head. The relationship between wool cut and the CC:SR ratio has an R^2 of 0.99 for the data range tested.

Similar data are available for lambing rate in Figure 4 for the years 1999 to 2003 from lambing to lambing. The relationship between lambing percentage and the CC:SR ratio had an R^2 of 0.90 for the data range tested. It should be pointed out that this property has been run with a focus on ecological renewal, for 30 years and has a very high standard of management.

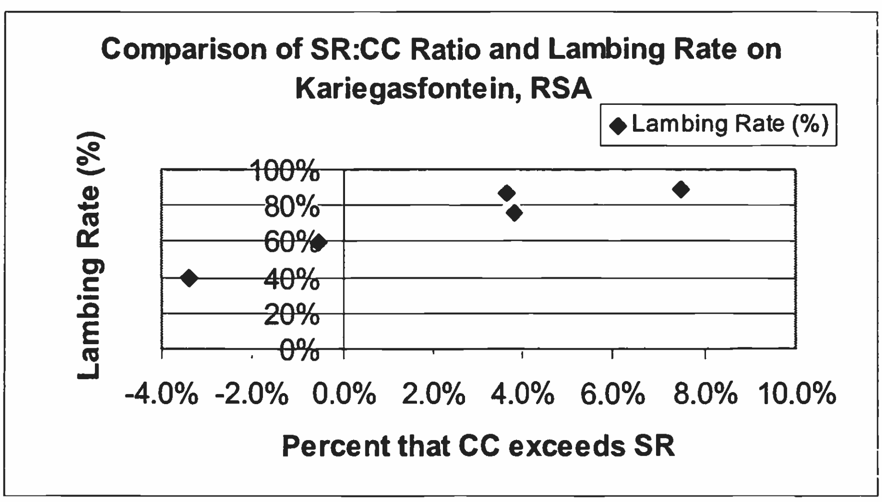


Figure 4. The relationship lambing rate and the percent by which estimated carrying capacity (CC) exceeds actual stocking rate (SR).

DISCUSSION

A number of common issues stand out when looking at the case studies collectively. These include:

- Rainfall amount, distribution and timing have an overriding influence on the ecology and businesses, even when stocking rate is matched to carrying capacity and plants are rested.
- Discussions with each manager reveal that each is now much more focused on the amount of pasture they leave behind in the full spectrum of seasons, than on how much they take.
- In most cases, the previous year's seasonal conditions had an effect on the subsequent year's production and profit. In other words, parameters are not only affected by what happens in the current year, but both good and poor seasonal and management effects are cumulative. Matching SR to CC is similar to a bank account. If it is overdrawn one year, then you have to have more in credit the following year to pay back the deficit as well as operate in the current year. This implies that a surplus, or ecological investment, needs to be cumulatively deposited and maintained over a number of seasons. How much do we need to leave behind for eco-maintenance, and how much for eco-expansion? Perhaps we should develop a ROEI or "return on ecological investment" indicator (McNaughton *pers. comm.*).
- Cost of production skyrockets in years when productivity (both animal unit and per ha) is low. High CoP reduces ROA.
- Hard data on ecological renewal are hard to find in commercial settings, however anecdotal evidence abounds. One of the problems with getting long term hard evidence has been the failure of GrassCheck to provide any useful data. While several properties have kept GrassCheck data for many years, it is virtually un-interpretable. RCS now recommends a basal area technique to graziers, but this has been only recent so no long term data are available. Evidence has however been previously published by McCosker (2000), Joyce (2000) and Sparke (2000).

The challenges for rangelands producers are therefore to:

- Structure their business to cope with the seasonal variability in rainfall. The difference between the T20 and AV illustrates that it is possible to have profits in bad years, albeit lower, but the correct strategies are necessary.
- Increase productivity (per head and per ha) faster than the ever upward creep in overheads. Our data (RCS, unpublished) indicate that extensively managed rangelands properties generally have high and increasing costs of production. This is because overheads have steadily climbed for the last 20 years, but productivity increases have stalled with diseconomies of scale.
- Manage the rangelands for ecological renewal while concurrently increasing productivity per head and per ha. To merely sustain the current level of health and productivity in the rangelands is both an economic and ecological folly. Obviously a healthier rangeland will sustain higher productivity. The constraint to this is not scientific knowledge but rather necessity, training and capital.
- Populate the rangelands. Increased productivity can only come about through more intensive management. However there is no evidence that intensification can occur extensively. Therefore the huge poorly utilized properties that characterize the extensively operated rangelands in Australia will need to be handled as smaller, well managed units. A direct comparison between 400,000 ha in the VRD and 400,000 ha in the Hughenden/Richmond region in Queensland shows the smaller properties have three times the stocking rate, higher per animal productivity and lower CoP than the VRD, under current management practices. Improved management practices have been shown to increase productivity in this Queensland region by a further 50%.

For too long, sustainability has been a catch-cry. Sustainability infers the maintenance of what we already have. More important than sustainability, is renewal. Renewal is about changing the way in which land and business is managed, to allow continuous improvement in the current ecological, human and economic condition of our resources.

Popular belief has been that it is not possible to achieve ecological renewal while at the same time improving livestock, lifestyle and profitability. This paper shows that through changes in management (introducing strategic and tactical rest to pastures, matching stocking rate to carrying capacity, and planning, monitoring and controlling management), graziers have been able to improve livestock productivity with the end result of a more profitable business. Anecdotal evidence of improved ecological condition of land has been easy to find, however hard evidence is still lacking.

REFERENCES

Joyce, S. (2000). Change the management and what happens – a producer's perspective. *Tropical Grasslands* 33: 223-229.

McCosker, T.H. (2000). Cell grazing – the first 10 years in Australia. *Tropical Grasslands* 33: 207-218.

Sparke, R. (2000). Cell grazing – a producers perspective. *Tropical Grasslands* 33: 219-222.

SPONSOR PRESENTATION

Jim Donaldson and Warwick Jones

Department of Agriculture, Fisheries and Forestry, GPO Box 858, Canberra ACT 2601

The agricultural and natural resource based industries operate in a competitive environment with many economic, environmental and cultural challenges. This means that we cannot address sustainability issues in isolation from the socio-economic context and there is a key role for Governments in supporting the role of Landcare and community empowerment through skills, knowledge and information that allow for local solutions.

The paper will canvass the role of the Australian Government in supporting the management of the rangelands for productivity and sustainability outcomes through the Landcare Program, Natural Heritage Trust and research activities. The paper will draw from relevant initiatives such as the Australian Collaborative Rangeland Information System in supporting provision and application of accessible and relevant information at a range of scales. It will also canvass the role of Landcare and other capacity building initiatives in enhancing the productive and profitable resource based industries.

MULGA (*ACACIA ANEURA*) DEATH ADJACENT TO HAUL ROADS IN THE NORTHERN GOLDFIELDS, WESTERN AUSTRALIA

M. Bertuch and E. van Etten

Centre for Ecosystem Management, Edith Cowan University, 100 Joondalup Drive, Joondalup, WA 6027

ABSTRACT

Increasing numbers of mulga (*Acacia aneura*) deaths have been observed adjacent to mine haul roads in the Northern Goldfields, Western Australia. Although there may be several causes of tree death, it is thought that increased soil salt levels, due to watering of the haul road with hypersaline water, and/or road shadow effect are the two most likely causes.

This study compared treated roads (watered with hypersaline water) and control roads (not watered) and the upslope and downslope sides of the roads. Tree canopy decline was significantly greater at treated road sites than control sites. The proportion of old dead trees was significantly higher at control road sites than treated road sites. The downslope side of roads (treated and control) showed a significantly higher proportion of both dead trees and recently dead trees. The downslope side of the treated road had significantly greater soil conductivity than the control road (both upslope and downslope) and the upslope side of the treated road. This suggests that runoff from watered roads causes salinity increases downslope, which in turn results in tree death.

Keywords: mulga; *Acacia aneura*; roads; salinity; road shadow; sheetflow

INTRODUCTION

The extraction and production of mineral and energy resources has occurred in Australia since European settlement. The discovery of gold and subsequent immigration led to the exploration and settlement of the remote interior (Howard 1996a). This area encompasses what is now known as the rangelands and occupies more than 75% of Australia, with 2% used for mining (Harrington *et al.* 1984; Commonwealth of Australia 2001). The majority of Australian gold mines are located in rangeland areas (Howard 1996a). Gold mining techniques have changed from alluvial and underground deposits to the large scale open-pit mining operations of today. This change in the scale of operations has seen the development of large pits, often intercepting the water table and increasing the need for disposal of mine pit water, and the construction of haul roads. These and other changes have led to an increased potential for environmental problems and an increasing need for environmental impact assessment before mining, appropriate environmental management during mining and effective rehabilitation of the land after mining (Farrell and Kratzing 1996; Howard 1996a).

Although the collective area of land disturbed by mining may be small and the life of a mine relatively short, dramatic impacts can occur to the local and surrounding environment during the operational period. This includes the exploration, mining or mineral processing phases or for the years after mining (Bell 1996; McQuade and Riley 1996). Mining impacts from infrastructure such as the pit, waste dump and tailings dam affect the major area of the mine and are usually confined to a discrete area. However, these are not the only impacts caused by mine infrastructure and others include haul roads, access roads, railways, conveyor belts, dump sites, airstrips, settlements and offices. Haul roads which link satellite pits with existing infrastructure have become popular in recent years on account of the costs associated with moving infrastructure such as crushers, mills, laboratories and offices. It has become easier and cheaper to transport ore from a satellite pit (usually between 10-50 km away) to a centrally established crushing and extraction plant. This however, has led to a substantial network of roads around mine sites often with detrimental effects on the surrounding landscape. In recent years at Placer (Granny Smith) mine site near Laverton, in Western Australia, there have been observations of increasing tree death along haul roads. Several factors have been thought to cause tree death; this paper concentrates on two of these, namely road shadow effect and salinity.

In the arid and semi-arid zones of Australia, surface or sheet-flow occurs on slopes between 0.2 and 2% rather than channelised flow (Ludwig *et al.* 1997; Wakelin-King 1999; d'Herbes *et al.* 2001). Depending on construction design, roads can impede the flow of water along the slope resulting in water starvation on the downslope side causing tree death (road shadow effect) and eventually changes in vegetation (Pringle *et al.* 1994). To date, road shadow effect has been identified across other areas of Western Australia including grazing land and road verges (Hussey and Wallace 1993). It therefore needs to be examined to see if it is a relevant problem and if improvements in road design can help to alleviate the problem. However, around the Placer (Granny Smith) mine site it has been speculated that road shadow effect is not the only cause of tree death, but that other factors or multiple factors are the cause.

Salinity is a major issue as haul roads at many mines are watered to suppress dust. Dust suppression is considered necessary for both safety and environmental reasons. Excessive dust is considered pollution and poses a health risk. Research at the Fimiston Pit, Kalgoorlie confirmed the importance of adequately watering the haul road surface to reduce dust emissions (Howard 1996b). Dust leads to a reduction in visibility for drivers on the haul road, which is a safety concern. At Placer (Granny Smith) the water used on the haul road is sourced from the Sunrise Pit and contains approximately 200,000 mg/L TDS (total dissolved solids). The use of pit water has two advantages. Firstly, it facilitates dewatering. Dewatering is the disposal of water, which accumulates in the bottom of the mine pit from groundwater interception and rainfall. Secondly, due to the scarcity of water in the arid zone, pit water is a convenient and economical source of water for use on haul roads. The salt in this water binds the soil to form a crust on the haul road, which further helps to suppress dust. The watering of haul roads is now considered normal practice in Western Australia and is a convenient way to dewater pits and suppress dust. Runoff of salty water from roads and the subsequent effects on soil need to be examined as part of this issue. It is hypothesised here that the 'Placer – Sunrise' haul road, which is watered to suppress dust and other local roads, which are not watered, will show differences.

The Mulga woodlands are one of the principal vegetation formations of the semi-arid and arid zone, (Beard 1990; Greig 1992). *Acacia aneura* (mulga) is a variable bushy shrub or small tree to 14 m tall with a number of characteristics being specific to provenance or ecotype (Randell 1992; William 2002). Mulga is widely distributed (landscape and soil types) over the arid areas of inland Australia, but is most commonly found on the lowland plains and sand plains (Greig 1992; William 2002). In terms of nutrient capture, transfer and hydrological regimes mulga plays an important role in arid landscapes (William 2002).

The tree form of mulga is such that its upward sloping branches and leaves capture up to 40% of the rain that falls on the canopy. These channel much of the intercepted water down the trunk (stemflow), increasing soil moisture close to the root zone (Harrington *et al.* 1984; Burnside *et al.* 1995; William 2002). The root systems of mulga are specially adapted to obtain water from the thin surface soil layer allowing it to exploit the moisture from even minor showers enhanced by stemflow (Greig 1992; Burnside *et al.* 1995; Wickens 1998; Brearley 2000). These extensive, radially extending root systems are likely to be of importance to this research.

METHODS

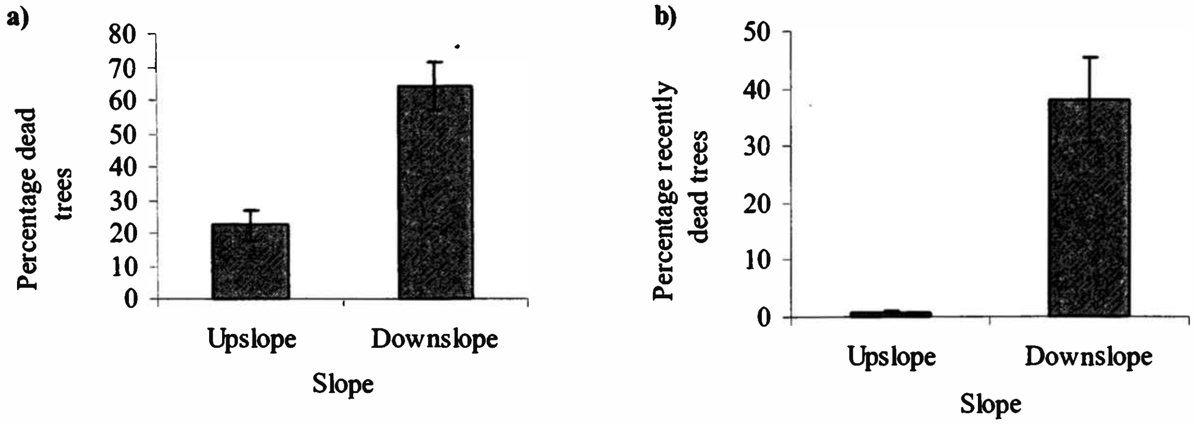
This research has been undertaken at Placer (Granny Smith) gold mine 25 km south of Laverton, Western Australia. The experimental design included a treated haul road (watered) and a control road (not watered). The treated road lies between the Granny Smith mine site and the Sunrise pit, is 30 km in length and has been watered 1-3 times daily since 1995. The control roads used were the Bindah Road and the Hacks Well Track, both of which are well-established roads, and are not watered. The presence of mulga was noted and the patterns of tree death were documented. This allowed for suitable site selection, which include mulga in both poor and good condition. Sites consisted of 2-3 adjoining quadrats. Quadrats were either 5x10m or 10x10m (with the 10 m side being parallel to the road). These adjoining quadrats also acted as a transect corresponding with distance from road edge. Altogether 20 sites were established (5 upslope and 5 downslope on the treated road and 5 upslope and 5 downslope on the control road). The treated and control roads intercepted an east-west slope of less than two degrees.

Within each quadrat, height, stem diameter and status of the mulga trees were noted. Status referred to whether the tree was dead or alive. For live trees the canopy volume, estimated as a percentage of the volume of a typical tree of full canopy, was recorded and for dead trees the 5 smallest branch/stem diameters were measured using calipers. This allowed for the dead trees to be classified as "recently dead" if the mean branch diameter was less than 1.5 mm and as "old dead" if the mean branch diameter was greater than 5 mm. The number of dead and alive trees (and per cent full canopy for live trees) was noted at two periods, once in 2000 and once in 2001, approximately a year apart. Within each quadrat, soil samples were taken with increasing soil depth (cm). Soil samples were taken from two areas within the quadrat and combined to form a bulk sample to overcome soil spatial variation within the quadrats. Soil samples were taken back to the laboratory and dried (100°C for 24 hours), sieved to 2 mm and then measured for electrical conductivity using the 1:5 ratio saturation method.

Data were analysed using two-way Analysis of Variance and *t*-tests in SPSS to examine mean differences between the variables measured and control and treated roads and the upslope and downslope sides of the roads.

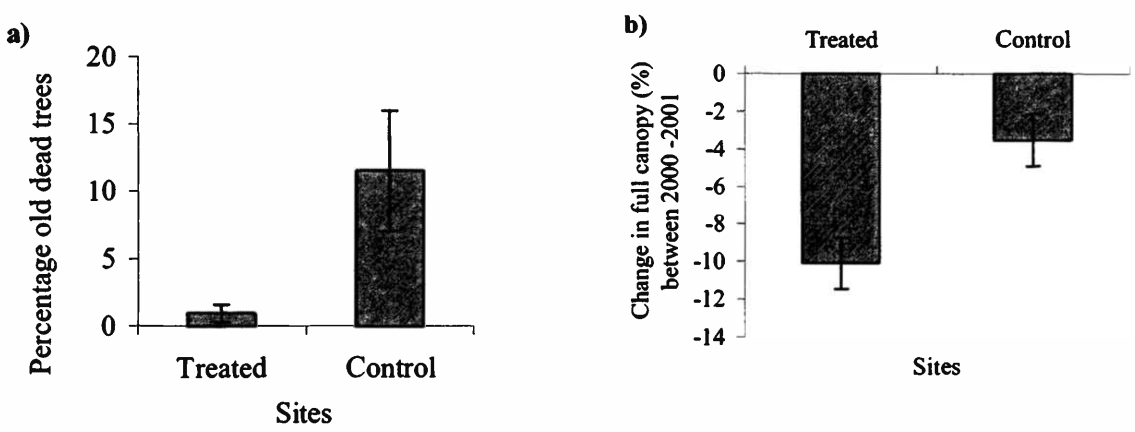
RESULTS

Two-way Analysis of Variance showed no significant interaction between treatment and position for dead trees, recently dead trees or old dead trees and therefore *t*-tests were used to analyse the data. The data for percentages dead trees, recently dead trees and old dead trees were arcsine transformed. The downslope sides of both the treated and control roads showed significantly more dead and recently dead trees than the upslope sides of the roads (Figures 1a & 1b). Of the average 65% of dead trees on the downslope side of the control and treated roads, an average 37% were recently dead. Of the remaining dead trees on the downslope sides of the roads, an average 10% were old dead trees, however this was not found to be significant.



Figures 1a & b. Mean percentage of **a)** dead (*t*=-4.78 p<0.001) and **b)** recently dead (*t*=5.5 p<0.001) trees at upslope and downslope sites on both treated and control roads.

There were significantly more old dead trees at control road sites regardless of side of the road (Figure 2a). The results of the tree canopy assessment between 2000-2001 showed that four trees died during that period (three trees from treated downslope sites and one tree from treated upslope sites). All of these trees had a canopy volume below 25% during 2000. However, although most of the trees alive during 2000 did not die, many of the trees on the treated road showed a significant decrease in canopy volume between 2000-2001 (Figure 2b).



Figures 2a & b. **a)** Mean percentage of old dead (*t*=2.0 p<0.001) trees; and **b)** mean change in per cent full canopy (*t*=3.4 p<0.01) between 2000-2001 at treated and control sites.

At 0-1 cm of soil depth there was a significantly higher electrical conductivity (EC) (µS/cm) on the downslope side of the treated road (Figure 3). The average EC on the downslope side of the treated road was 3636 µS/cm compared to the downslope side of the control road, which had an average EC of 162 µS/cm. This pattern continued with increasing soil depth, for instance at 1-3 cm soil depth the EC on the downslope side of the treated road averaged 6068 µS/cm whilst the downslope side of the control road had an average EC of 274 µS/cm. However, the upslope side of the treated road at 0-1 cm soil depth showed a much lower average EC of 526 µS/cm, but this was still higher than the upslope control sites at 0-1 cm soil depth, which averaged 149 µS/cm (Figure 3).

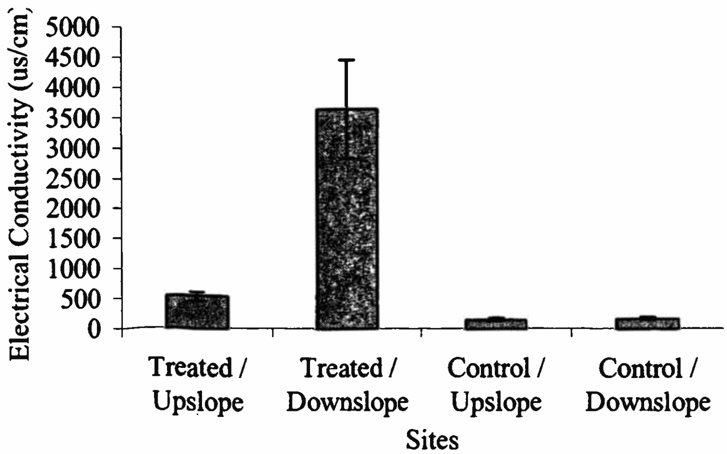


Figure 3. Electrical Conductivity (µS/cm) at 0-1 cm soil depth (interaction, $F=36.1$, $df=3$, $p=<0.001$).

DISCUSSION

Following visual assessments at both control and treated roads it was observed that there were substantially more dead mulga on the downslope side of the treated road than anywhere along the control road. In particular there appeared to be many recently dead trees within the first 5-10 m from the road edge beyond which mulga appeared to be alive. Another observation made along the treated road was that salt scald was often present on the soil surface amongst the road edge vegetation, particularly on the downslope side. The results presented here accord with the observations made.

A higher percentage of dead trees was found on the downslope side of both the control and treated roads. The aim was not to demonstrate that these areas had more dead mulga as this was expected from the observations, rather it was to show that within tree patches the proportion of dead mulga was similar between control and treated roads, but varied according to side of the road. This result may reflect sampling bias as sites selected on the downslope sides of the roads contained predominantly dead trees. More important was the proportion of recently dead and old dead trees at sites. Over half of the dead trees on the downslope side of both the control and treated roads were classified as recently dead. Based on observation it was expected that the downslope side of the treated road and not both the treated and control roads would show this result. The results thus far could be attributed to road construction impeding sheetflow and leading to road shadow effect (the death of trees) primarily on the downslope side of the road and that this may be occurring at both treated and control sites.

In the case of old dead trees the justification for road shadow effect being the cause is less clear. The control roads are older than the treated and this would account for the higher proportion of old dead trees found on this road if road shadow effect was the cause. However, road shadow effect is said to cause tree death downslope but the percentage of old dead trees is similar on both sides of the control road. This pattern of old dead trees may reflect other historical factors, such as differences in grazing regimes, not examined as part of this study.

Although the proportion of trees classified as recently dead was similar between treated and control roads, canopy condition declined far more on the treated road from 2000 to 2001. This is an important finding as it suggests other underlying causes of tree decline or death rather than road shadow effect because of the magnitude of the decline and because trees on either side of the road were similarly affected. A potential cause that was examined was enhanced soil salinity adjacent to the treated road. The average electrical conductivity on the downslope side of the treated road was over 20 times higher than on the downslope side of the control road. The upslope side of the treated road also displayed a higher electrical conductivity and although it was approximately 7 times lower than that on the downslope side of the treated road it was still 3.5 times higher than at the upslope control sites on average. The conclusion therefore is that salt in the water which runs off the watered road is likely to have contributed to the most recent tree declines adjacent to this road.

Soil degradation encompasses many issues including that of salinisation (Harrington *et al.* 1984; National Research Council (US) Committee on Rangeland Classification 1994). In arid climates salts tend to accumulate in soil, particularly near the soil surface, as they are not leached by regular rainfall (McBride 1994). As mentioned previously the root systems of mulga are specially adapted to obtain water from the thin surface soil layer (Greig 1992; Burnside *et al.* 1995; Wickens 1998; Brearley 2000) and consequently increased salt levels in this layer would be expected to affect water uptake.

The management options for Placer (Granny Smith) related to this research are still being considered. In an ideal world the watering of haul roads with hypersaline water should be stopped. However, considering the lack of alternative water sources this is unlikely. A reduction in the level of salts in the water may be a good starting point. However, without knowing at what salinity threshold mulga begins to decline it is difficult to set such levels. There are other dust suppression products available that can be applied to roads, although many of these need water to act as a dispersing agent. Road design is another management option and is mainly oriented to alleviating road shadow effect. Roads in northern Western Australia have in the past been designed to allow water to be redistributed by installing additional culverts and drains (Dames and Moore 1984). However, experience at Placer (Granny Smith) has shown that these do not always work. Drainage culverts on the downslope side of the treated roads at Placer (Granny Smith) were found to contain dead mulga at the end of culverts and beyond. Culverts may work by redistributing sheetflow, though when hypersaline water has been applied to the road it seems to move problems further into the landscape. Other options on haul roads may include the use of culverts with pits to contain the salt residue. However, what happens during large rainfall event in this scenario is not known. Another very important issue is that of grading and avoiding leaving salt laden spoils on the road edge.

While gold mining and ore-processing methods are essentially very similar across Australia, there exists a wide range of environmental management issues driven by the differences in climate, geology and history (Howard 1996a). It is therefore appropriate for the mining industry to be concerned with protecting the whole environment in which it works or has influence upon (Happs and Kinnear 1992), and that companies study and ameliorate adverse effects by seeking relevant management options which can also accomplish their sustainability and environmental objectives. It is unacceptable for companies to sacrifice good quality land such as that along haul roads through inadequate knowledge and management.

ACKNOWLEDGEMENTS

We gratefully acknowledge the following people for logistical help with this research: Placer (Granny Smith), in particular Rory Lamont, Melanie Hayhow, Nathan Russell and Pamela Soto for helping to organise flights, accommodation and equipment on site; the Centre for Ecosystem Management for conference funding; The Australian Rangeland Society for sponsorship of student registration for this conference; the School of Natural Sciences for postgraduate funding and support; and Professor William Stock, Dr David Goodall and Ms Rebekah Kenna who willingly proof read this paper and abstract and provided valuable feedback.

REFERENCES

Beard, J.S. (1990). *Plant Life of Western Australia.* Kangaroo Press Pty Ltd., Kenthurst, NSW.

Bell, L.C. (1996). Rehabilitation of Disturbed Land. *In* 'Environmental Management in the Australian Minerals and Energy Industries: Principles and Practices.' (Ed Mulligan, D.R.). University of New South Wales Press, Sydney, pp.227-261.

Brearley, D.R. (2000). The Diversion of Windich Creek: Implications on Downstream Vegetation, Report 00-0134. Prepared for Placer Dome Asia Pacific by Curtin Consultancy Services Ltd, Perth, Western Australia.

Burnside, D., Holm, A., Payne, A. and Wilson, G. (1995). *Reading the Rangeland: A Guide to the Arid Shrublands of Western Australia.* Department of Agriculture, South Perth, Western Australia.

Commonwealth of Australia (2001). *Rangelands - Tracking Changes. Australian Collaborative Rangeland Information System.* National Land and Water Resources Audit, Turner, ACT.

Dames and Moore (1984). *Perth to Darwin National Highway - Newman to White Springs. Draft Environmental Review and Management Programme and Environmental Impact Statement,* Main Roads Department, Perth, Western Australia.

d'Herbes, J., Valentin, C., Tongway, D.J. and Leprun, J.-C. (2001). Banded Vegetation Patterns and Related Structures. *In* 'Banded Vegetation Patterning in Arid and Semiarid Environments: Ecological Processes and Consequences for Management.' (Ed Seghieri, J.). Springer-Verlag Inc., New York, pp.

Farrell, T.P. and Kratzing, D.C. (1996). Environmental Effects. *In* 'Environmental Management in the Australian Minerals and Energy Industries: Principles and Practices.' (Ed Mulligan, D.R.). University of New South Wales Press, Sydney, pp.14-46.

Greig, D. (1992). *Colour Guide to the Wildflowers of Central and Western Australia.* CollinsAngus and Robertson Publishers Pty Limited, Pymble, New South Wales.

Happs, J.C. and Kinnear, A. (1992). *Soil Degradation: An Australian Perspective.* Longman Cheshire Pty Ltd., Melbourne, Australia.

Harrington, G.N., Wilson, A.D. and Young, M.D. (1984). *Management of Australia's Rangelands.* CSIRO Publications, Melbourne, Australia.

Howard, R.K. (1996a). Introduction to Gold. *In* 'Environmental Management in the Australian Minerals and Energy Industries: Principles and Practices.' (Ed Mulligan, D.R.). University of New South Wales Press., Sydney, pp.317-320.

Howard, R.K. (1996b). Environmental Management at KCGMs Operations in the Arid Zone of the Western Australian Goldfields. *In* 'Environmental Management in the Australian Minerals and Energy Industries: Principles and Practices.' (Ed Mulligan, D.R.). University of New South Wales Press, Sydney, pp.320-348.

Hussey, B.M.J. and Wallace, K.J. (1993). *Managing Your Bushland.* Department of Conservation and Land Management, Perth, Western Australia.

Ludwig, J., Tongway, D.J., Freudenberger, D., Noble, J. and Hodgkinson, K. (1997). *Landscape Ecology, Function and Management*: Principles from Australia's Rangelands. CSIRO Publishing, Collingwood, Australia.

McBride, M.B. (1994). Salt-Affected and Swelling Soils. *In* 'Environmental Chemistry of Soils.' Oxford University Press, New York, USA, pp.273-307.

McQuade, C.V. and Riley, S.J. (1996). Water Management. *In* 'Environmental Management in the Australian Minerals and Energy Industries: Principles and Practices.' (Ed Mulligan, D.R.). University of New South Wales Press, Sydney, pp.189-226.

National Research Council (US) Committee on Rangeland Classification (1994). *Rangeland Health: New Methods to Classify, Inventory and Monitor Rangelands*. National Academy Press, Washington, D.C. United States.

Pringle, H.J.R., Van Vreeswyk, A.M.E. and Gilligan, S.A. (1994). *An Inventory and Condition Survey of the North-Eastern Goldfields, Western Australia*, No. 87. Department of Agriculture. Perth, Western Australia., South Perth, Western Australia.

Randell, B.R. (1992). Mulga. A revision of the major species. *Journal of the Adelaide Botanical Garden*. 14: 105-132.

Wakelin-King, G.A. (1999). Banded mosaic ('Tiger Bush') and sheetflow plains: a regional mapping approach. *Australian Journal of Earth Sciences*. 46: 53-60.

Wickens, G.E. (1998). *Ecophysiology of Economic Plants in Arid and Semi-Arid Lands*. Springer-Verlag, Berlin, Germany.

William, J. (2002). Fire Regimes and Their Impacts in the Mulga (*Acacia Aneura*) Landscapes of Central Australia. *In* 'Australian Fire Regimes: Contemporary Patterns (April 1998 - March 2000) and Changes since European Settlement.' (Ed Williams, J.). Department of the Environment and Heritage, Canberra, pp.1-58.

CLIMATIC PLACE: A SOCIO-CULTURAL GEOGRAPHY OF CLIMATE RISK MANAGEMENT

P. Leith

School of Geography and Environmental Studies, University of Tasmania,
Private Bag 78, Hobart, 7001

ABSTRACT

Between November 2003 and February 2004, I conducted in-depth interviews with graziers in three areas of the semi-arid rangelands of NSW and Queensland. Analysis of these interviews provides insights into some of the socio-cultural contexts of climate information communication between scientists and graziers, as well as the ways in which climate information and knowledge are propagated, adopted, validated and contested within grazing communities. Climate in this sense is not only statistical or physical, but also experiential and inter-subjectively constructed. It can be described in terms of "climatic place" – the way weather is heaped up in the individual and social memory to become construed as a feature of a place. Narratives of climatic place are increasingly inclusive of scientific climate information, often imperfectly translated. Understanding both the socio-cultural contexts of communication and use of scientific climate information can help improve the way information is delivered and integrated into decision-making in the semi-arid rangelands.

INTRODUCTION

In this paper I explore the boundaries between formal scientific ways of assessing climatic risk, in terms of spatially extensive climatic oscillations like the El Niño Southern Oscillation (ENSO), and the ways that graziers in three areas of the semi-arid rangelands are using various local, regional, international and scientific sources to inform their climate risk related decisions. These decisions are always context dependent and, after providing a brief methodological background to the research, I explore some of the contexts in which climate risk decisions, particularly stocking decisions, are made. With reference to interviews with graziers, I highlight the primacy of situational factors in informing climate risk decisions before examining how anticipatory factors are included in these decisions. Among these anticipatory considerations, scientific climate information appears increasingly prevalent, though the ways graziers relate to this information, and to those who produce it, varies widely between individuals and groups. The use of locally derived anticipatory climate information is similarly variable. Similarities between scientific and local sources of information are described here in terms of the *visibility* and *recurrence* of both *signals* and *patterns*.

Semi-structured interviews highlighted ways scientific climate information, when employed, is used in contingency with a variety of other sources of information and, perhaps most influentially, with local knowledge that is experiential, and socially mediated. The implications of this contingent and context-dependent use of climate information throw into question two common assumptions that have informed the development and dissemination of scientific climate information: that 'uptake' of climate information can be evaluated, and; that seasonal outlooks are only of value if they change a decision.

METHODOLOGY

Qualitative examinations of the nexus between science and society can provide insights into practices, perceptions and relationships but also into how these are constituted. Where statistically representative, quantitative work in the social sciences has been likened to satellite imagery, providing "a broad overview of public opinion", qualitative studies are akin "to exploration on the ground"

(Kempton *et al.* 1995, pg.18). The 'ground' explored here can be described geographically as the three circular areas, of *c.*100 kilometre radius, centering on Longreach, QLD; Barringun on the NSW/QLD border (between Bourke and Cunnamulla); and Hillston in Western NSW. While these areas have a similar median annual rainfall, there are enormous differences in their seasonality, land systems, production capabilities and numerous other factors. Within the areas, the variety of land systems and grazing operations confound simple comparisons. All three areas, though, are periodically affected by ENSO-related drought and at various times statistical climate outlooks provide a potentially useful tool for managing climate risk.

In this research I have sought out a diversity of managers' perspectives through adapting a purposive sampling strategy aptly named 'rhizomatic sampling' (Stehlik *et al.* 1999). This technique allows rapid development of networks through engagement of key informants who are familiar with the local grazing community. These key informants ranged from stock and station agents and wool brokers to a retired grazier, an employee of a local NGO, a public librarian, and more. They provided contact details for managers who they considered to manage for climate risk in a diversity of ways. They also legitimated 'cold calls' by allowing their names to be cited in initial telephone contacts with managers. A minimum of three key informants was found for each region. Their 'networks' were broadened by requesting other contact details from participants after they were interviewed in their own homes.

While the geographical *areas* might be considered as three collective case studies, they are not. Case studies must be in some way bounded (Stake 2000, pg. 440). Although these areas are geographically prescribed, the social, business and familial networks of their residents rarely are. In the climate risk management tradition of Tyson and Kidman, a large proportion of the participants had one or more properties outside the study areas, and one even had properties in more than one of these areas. Families were often far afield, though even from a distance, business relationships between participants and their families were frequently maintained. These and other features of graziers' business structures affect how climate risk is not only managed but perceived. People's historical, familial and social relationships with other places allow understanding of different local and regional climates and affect how their own climate is understood and managed. Necessarily then, rather than being case studies of areas, this is a study of 'interconnected networks of people' (Neumann 1997, pg. 204) in different places, and of how their knowledges of their climate intersect with scientifically derived climate risk information. The geographical parameters bounding the study areas were defined to make this study practically achievable through delimiting the spatial extent of the networks of participants and key informants, and demarcating areas for closer historical analysis.

RESULTS AND DISCUSSION

The use of information about future climatic risk, however derived, is always embedded in the situational context. For instance, as illustrated on the left side of Table 1, the majority of participants stated that the most important influence on their stocking rate decisions was quantity and quality of standing feed. This situational factor was rarely measured, quantified or recorded by participants. A small number of interviewees maintained grass-check sites and records but the large majority assessed the feed heuristically as they travelled around their country. Taking measure of the feed on a given property, or the resilience in that country, was less scientific or formulaic, or done using rules of thumb. Instead participants tended to repeatedly gauge the changes in the country as they appeared. Such assessments are usually informed by social and inter-generational memory as well as experiential knowledge of how a body of feed will hold out, depending on an array of factors (see Table 1) which vary from one manager or situation to the next. They are further tempered by the management ethos of an individual, family or group. As such, property decisions are rarely straightforward or prescriptive and, in family operations, are nearly always contingent upon the social, economic and environmental contexts in which the decisions are faced. By way of example, as one grazier put it:

If you walk into a bank and are looking for finance, I've yet to meet a bank manager, who will say: "Is your wife on side?". And that is the most critical point of any management decision to be made in arid land management. Because if you haven't got the backing of your partner and the family, everything breaks down. So you might say, "well, what's this got to do with forecasting?" or whatever, but it has everything to do; as to whether you take any notice of all this, or whether you *can* take any notice of this (male grazier, border area, QLD).

This analysis, then, recognises the importance of various situational factors that influence such things as stocking rate decisions, but draws focus on the anticipatory factors, such as long-term climate outlooks, and how they play a role in such decision-making.

The right side of Table 1 condenses and categorises the most common responses to a question about how managers assess the risk of drought or dry conditions in coming months or seasons. Here the responses are based both on sources of scientific information and on local observations and experience. While keeping track of the Southern Oscillation Index (SOI) ranks highest among these factors for all the areas together, this trend is not apparent in individual areas. It must be stressed at this point that these frequencies are descriptive rather than statistically significant and are included here as a way into the more detailed qualitative analyses which provide insights into, for instance, the way different factors are weighted as 'decision stakes'.

Table 1. Ranking of the first ten factors (all areas) that influence stocking rate decisions and drought risk assessments by area and frequency.

What factors are important in influencing stocking rates? (first four mentioned)	ALL AREAS (n=70)	LONGREACH (n=25)	BORDER (n=20)	HILLSTON (n=25)	How do you assess the risk of drought or dry conditions in coming seasons? (first three mentioned)	ALL AREAS (n=70)	LONGREACH (n=25)	BORDER (n=20)	HILLSTON (n=25)
quantity and quality of standing feed	50	19	16	15	keep track of SOI	12	5	3	4
time of year	26	11	9	6	law of averages (dry and wet periods)	9	1	3	5
recent climatic/rainfall conditions	16	8	4	4	don't have long term strategy	8	2	4	2
market	11	8	1	2	Bureau of Meteorology (www)	8	1	3	4
water available	7	3	3	0	conservative estimates of what it might happen	7	1	5	1
health of animals/condition of stock	7	3	1	4	seasonal outlooks generally	7	2	0	5
stored fodder on hand	6	0	0	6	Roger Stone	6	5	1	0
SCOs general (BoM/QCCA/others)	6	2	2	2	feel for seasons through many generation	6	1	0	5
stock/crop balance	6	0	0	6	feed in hand at certain times	4	4	0	0
ground cover/ soil protection	5	0	2	3	gut instinct	4	3	0	1

A relatively high number of respondents said that they do not have a long term strategy for assessing climate risk. Some went on to talk about the variety of information that they do take some heed of in anticipatory decision making. Others made it clear that they would not be influenced by climate outlooks, but at other stages of the interview mentioned El Niño or climate forecasters in describing how and when they made decisions to lighten off. Such discrepancies were not uncommon in relation to assessment of climate risk and raise questions about assessing 'uptake' of climate risk information.

The notion of uptake is also problematic in the context of understanding and use of scientific climate information. General ideas may be comprehended; principles or concepts understood, yet practices may remain unswayed by these gleanings because they are deemed to lack *saliency*, *credibility* or *legitimacy* (Cash 2001) either in themselves or their sources. In cases where individuals have engaged with the science though not necessarily employed it to inform decision-making (and particularly where they have engaged with the scientist), a reflexive relationship is established:

There's a lot of people in the community that cling to straws. Doesn't matter what part of the community they come from. And the moment someone like Roger Stone comes out and says "The outlook for the next three months is looking pretty promising", a lot of people get their hopes up a lot and then he comes out and says "Oh, you know, the Pacific Ocean temperatures are warming up too much and the SOI is falling." But you know, I've had a few discussions with Roger Stone, and its only now that he's starting to address what I've been asking him now for about four years, five years, and that is the SOI and El Niño effect, it really only affects eastern Australia. How far west does it come from the seaboard? And Roger himself will acknowledge that by the time you get to about us, it's a hit and miss as to whether it has an effect or doesn't have an effect. That's why some people out here do quite well in an El Niño. Most of the weather here comes from the Indian Ocean.... right up until recently, Dr Roger Stone's group has not been trying to really assess the correlation between the Indian Ocean atmospherics and the Pacific. I think the Indian Ocean means more to most of us than the Pacific (male grazier, Longreach area, QLD).

Such reflexive relationships with scientists and their information products change local narratives by, for instance, challenging the simplifying generalisations of the media or other local graziers. Hence, relationships between individual graziers and experts were often reflected not only in individual interviews but in small locales or networks where climate narratives were more "scientised". This "scientisation" often appeared to have been seeded by one or more individuals; through Local Best Practice Groups, Landcare Groups or social functions. Such individuals had usually attended climate workshops which were reported upon favourably, if predominantly in that the manager's conception of the factors that influence the local climate and weather were challenged or broadened.

Conversely, in other locales, climate researchers were often conflated with weather forecasters in the third person plural – "they". Probabilistic statements about seasonal climatic risk were translated as definitive. For example, carefully caged statements such as "four of the eleven sampled Global Circulation Models surveyed indicate that the Pacific Sea-Surface Temperatures may return to El Niño-like conditions in the Autumn of 2005" became: "they reckon we're going back into drought after Autumn". While some probabilistic climate communication issues have been described psychologically (Nicholls 1999; White 2000), they also present an interesting case of the socio-cultural translation of science into a contestable form. Because probabilistic climate risk models can never be wrong, *per se*, they are difficult to validate through personal experience, and naïve uptake would require that trust in a model's reliability be absolute. When several models (or their proponents) appear to contradict one another, such trust becomes increasingly problematic.

Most inter-annual and inter-decadal models operational in Australia are historical and statistical (see McKeon *et al.* these proceedings). Their output, however, still frequently exists as 'forecasts' rather than as historical and spatial correlations. That said, a relatively high level of public engagement with SOI values and with analogue years (years in which similar SOI or SST conditions prevailed) points to the salience of *visibility* and *recurrence* of both patterns and signals. This can be highlighted by examining climate variability at various time scales along with a consideration of how climate is discussed locally. On a shorter timescale, the ascendance of consideration of the MJO (Madden-Julian Oscillation, or Forty-day wave) in decision making in western QLD, illustrates a rapid adoption of knowledge in response to a highly visible and frequently recurrent pattern:

There was hardly a person that you'd talk to that didn't, in February, or January [2003], that wasn't working on the 40-day oscillation. Of all the climate things that we listen to up here I reckon the 40 day oscillation or the MJO as they call it, what is it? The Madden Julian Oscillation? [laughs]. Probably carries more weight than anything. It's had a good run. I don't think it will always have a good run. I think they would have picked it up already just in rainfall charts, you know you would have just picked up this coming through all the time.... and also it's very pointed, just at the moment, because it is very dry and everybody's hanging out for rain, the prices [of stock] are very dear, so people are setting targets a bit (male grazier, Longreach).

The relative visibility and distinct frequency of the MJO and its rapid assimilation into certain local climate narratives, contrasts markedly with inter-annual and inter-decadal climate variability and even more so with timescales usually associated with global climate change. Participants often contested anthropogenic climate change on the grounds that climate has always changed, and illustrated this with reference to the geological history of the "country" in which they lived, its rocks and fossils. Climate change was often seen as an inevitable pattern of global and local history, remembered through the landscape itself, and recurring at indeterminate frequency.

Two decades ago, and for the two centuries before that, anticipatory climate risk assessment in Australian agriculture was entirely based on local knowledge of patterns and signals at local, regional and international scales. Numerous local hypotheses have stemmed from this, and though they are generally treated with scepticism within grazing communities they are often referred to. Old hands bear much of the accumulated understanding, particularly those with good memories and sharp observational skills. Many managers reported that they listened to credible old hands who frequently cage any predictions in terms of climatic and ecological patterns and histories; similarities between years inform how a given year is 'shaping up' and what *might* be expected. In this, the recurrence and visibility of patterns is again related through the landscape itself.

Climate and weather conversations are often about interactions between atmospheric conditions, plants and animals. They are both ecologically informative and place-specific. Their pre-eminence among local narratives gives them multiple roles: they are not just ice-breakers or chit-chat, but through their pervasiveness convey a deeper understanding of (situational) ecological factors affecting the broader locale or region. From such conversations over days, months and years, any given conditions are put in the context of the history and geography of that region and thus inform a relative understanding of the ecological and climatic situation together for any given place, as well as the anticipatory climatic risk faced. I have called this experiential and inter-subjective construction of the local climate 'climatic place'. It constitutes the local climate in terms of the way weather accumulates in the individual and social memory and so becomes a feature of the place. It is far removed from existing definitions of climate as either "the statistical assemblage of the weather in a region or at a place", or "the thermodynamic/hydrodynamic status of the global boundary conditions that determine the concurrent array of weather patterns" (Bryson 1997, pg. 451). Climatic place is closer to the climate to which McIntosh *et al.* (2000, pg. 24) refer in asserting that "we are all collectively paleoclimatologists".

CONCLUDING COMMENTS

Within the grazing communities that are the focus of this research, scientific climate risk information was seen to be variably but increasingly prevalent in the local narratives of weather and climate. I have briefly described these narratives here in terms of climatic place and provided some examples of how the interactions between climatic risk science (and scientists) and local grazing communities, is altering the narratives and thereby local decision-making. Within these narratives the saliency and legitimacy of patterns and signals in a local, regional, and scientific sense, are influenced by their *visibility* and *recurrence*.

Climate researchers are aware that "institutional and human capacity building" are "as much contextualised by deep social, cultural and historical factors as they are by complex atmospheric, landscape, economic and policy considerations" (Kiri-ganai Research Pty Ltd 2004). However, in much climate risk research the uptake of information is equated with changing decisions for the better. Such conceptualisations of how climate information exists in the decision-making frames of graziers in the semi-arid rangelands simplify the contingencies upon which climate risk decisions, such as altering stocking rates, are made. Scientific climate information may be most influential through the way it is translated and inevitably contested in local narratives. It appears to be within these everyday conversations and interactions that situational and anticipatory climatic risk is negotiated.

The ways in which scientists and government extension agents have interacted with graziers on an individual or community level has influenced narratives of climatic place, often within quite narrow locales or networks. Such nexus could be fruitfully extended to develop and maintain links between science and society through *interactive* formats and media, particularly internet, radio and workshops, which allow the contextual and contingent nature of climate risk assessment to be communicated *between* land managers and the scientists or extension agents.

Assessment of climatic risk is highly context dependent, and statistical or numeric modeling of climate variability only informs a relatively minor part of most climate risk related decisions. Despite this, the grazing communities that were the subject of this research are increasingly including climate science information in their climate and weather conversations. These conversations are informed by a complex interaction between science, various media, personal interactions and politics. I have briefly illustrated some conspicuous features of the complex, local and socio-cultural contexts in which risk assessments are made by graziers. These raise questions regarding two of the normative assumptions pertaining to the development and dissemination of climate risk information; firstly, that 'uptake' of climate information can be evaluated; and secondly; that seasonal outlooks are only of value if they change a decision. Just as the factors which lead to the development of an El Niño event are contingent rather than simple and causal, the nature of situational and anticipatory local risk assessment make it difficult to attribute risk decisions to any individual factor. Also, evaluating how graziers understand and use climate information is complicated by their reflexive engagement with climate science and scientists. Qualitative research can, through examining relations and interactions, provide a more nuanced analysis of the impact of scientific information on local decision making.

ACKNOWLEDGEMENTS

Thanks to graziers and key informants for their time and considered responses. This research would also not have been possible without the financial support of the Land Water and Wool Climate Variability sub-program, a joint initiative of Land and Water and Australian Wool Innovations. In-kind support of QCCA (now PPS), QDNRM (now QDNRM&E) and NSW Agriculture (now NSW DPI), Bourke, was also immeasurably valuable. Thanks also to my supervisors, Dr. Peter Hay, Dr. Elaine Stratford and Professor Frank Vanclay, for editorial comments. Errors or oversights remaining are solely my own. Thanks to my wife, Cath, for her support through the fieldwork.

REFERENCES

Bryson, R.A. (1997). The Paradigm of Climatology: An Essay. *Bulletin of the American Meteorological Society* 78: 449-455.

Cash, D.W. (2001). In Order to Aid in Diffusing Useful and Practical Information: Agricultural Extension and Boundary Organizations. *Science, Technology, & Human Values* 26(4): 431-453.

Kempton, W., Boster, J. and Hartley, J. (1995). *Environmental Values in American Culture.* MIT Press, Cambridge, MA.

Kiri-Ganai Research Pty Ltd (2004). Proposal for Cooperative Research Centre - Climate Risk Technologies: Draft Business Plan, Toowoomba.

Mcintosh, R.J., Tainter, J.A. and Mcintosh, S.K. (2000). Climate History and Human Action. *In* 'The Way the Wind Blows: Climate History and Human Action'. (Eds R.J. McIntosh, J.A. Tainter and S.K. McIntosh). Columbia University Press, New York, pp. 1-41.

Neumann, W.L. (1997). *Social Research Methods. Qualitative and Quantitative Approaches.* Allyn and Bacon, Boston MA.

Nicholls, N. (1999). Cognitive Illusions, Heuristics and Climate Prediction. *Bulletin of the American Meteorological Society* 80: 1385-1397.

Stake, R.E. (2000). Case Studies. *In* 'Handbook of Qualitative Research'. (Eds N.K. Denzin and Y.S. Lincoln). Sage, Thousand Oaks, London and New Dehli, pp. 435-454.

Stehlik, D., Gray, I. and Lawrence, G. (1999). Droughts in the 1990s: Australian Farm Families Experience. Rural Industries Research and Development Corporation, Canberra.

White, B. (2000). The Importance of Climate Variability and Seasonal Forecasting to the Australian Economy. *In* 'Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems - the Australian Experience'. (Eds G.L. Hammer, N. Nicholls and C. Mitchell). Kluwer Academic, The Netherlands, pp. 1-22.

AN INTRODUCTION TO THE GYPSOPHILOUS VEGETATION OF SEMI ARID AND ARID SOUTHEASTERN AUSTRALIA

M.J. O'Keefe, M.E. Westbrooke and S.K. Florentine

Centre for Environmental Management, University of Ballarat, PO Box 663, Ballarat VIC 3353

ABSTRACT

The growth of plants in soils rich in gypsum has received little attention. Research is being undertaken to investigate the degree to which there is a characteristic suite of species specifically associated with these soils and the nature of their adaptation to cope with high levels of sulphur and other problems. Many areas with high gypsum content have been subject to high levels of disturbance from open-cut mining. In this paper, some preliminary findings in relation to species occurrence is presented along with lists of species identified as potential gypsophiles. A program is outlined to investigate how plants are adapted to cope with gypsophilous soils.

INTRODUCTION

The vegetation associated with outcrops of gypsum in arid and semi-arid regions of Australia has received little attention. Plants associated with gypsum are referred to as gypsophiles, while gypsophily refers to the ability of a plant to tolerate gypsum. There appears to be some overlap between gypsophilous and saline flora. Significant deposits of gypsum (hydrated calcium sulphate) occur in Victoria, South Australia, Western Australia, Northern Territory, Queensland and New South Wales, where mean annual rainfall is less than 400 mm. Many otherwise widespread species are not recorded on gypsum soils, which have been classified as floristically poor. This suggests that gypsum has an adverse effect on most plant species. What this effect is, and how some plants have become adapted, form the basis of this research. To understand gypsophily, both the benefits and disadvantages of the gypsum substrate must be investigated. This research is important to enable the appropriate management of vulnerable or threatened taxa that have a known association with gypsum, and to guide the appropriate rehabilitation of gypsum mines following suspension of operations. Fleshy Minuria (*Kippistia suaedifolia*), family Asteraceae, provides an ideal opportunity to investigate the ecology of gypsophiles in Australia. An apparently obligate gypsophile, *K. suaedifolia* is endangered in NSW and considered vulnerable in Victoria. However, preliminary studies have revealed a population of almost 100,000 plants on exposed gypsum at an abandoned mine in the Raak Plain, northwest Victoria and close to a million plants at another abandoned mine near Ivanhoe, western NSW. This latter site is one of only three known occurrences of the species in NSW. Two key questions are being investigated:

- Is there a suite of plant species regularly associated with gypsum?
- How are plants adapted to cope with gypsophilous soils?

As an example of an apparently obligate gypsophile, the ecology of *K. suaedifolia* will be investigated in natural and disturbed environments.

SPECIES ASSOCIATED WITH GYPSOPHILOUS SITES

Method

In a preliminary investigation, disturbed sites associated with gypsum open cut mines around Ivanhoe and relatively undisturbed sites in and around the Scotia Discharge Complex in western NSW were investigated (Fig 1.). The latter sites have been subject to some elevated grazing pressure but no mining activity. At the Scotia site, a population of *K. suaedifolia* had been discovered during previous vegetation surveys (Westbrooke *et al.* 1998). At each site all species occurring were recorded and their life–form noted. This list of species was compared to data on possible gypsophiles from Parsons (1976), David Symon (SA Herbarium, *pers. comm.*, 2003) and Neville Walsh (Melbourne Royal Botanic Gardens, *pers. comm.*, 2003).

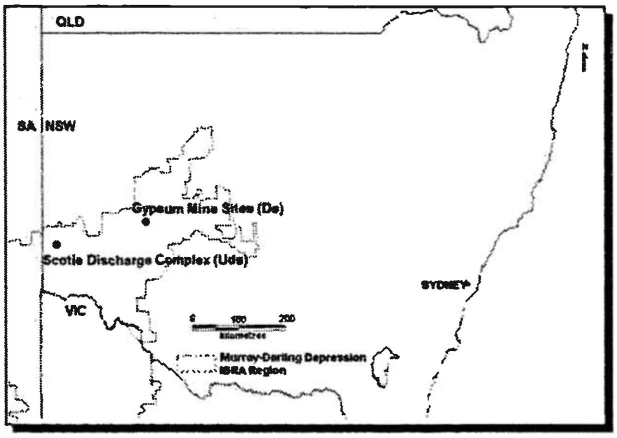


Figure 1. Location of NSW study sites included in this paper

RESULTS

Data from Parsons (1976) together with unpublished data from Symon (SA Herbarium, *pers. comm.*, 2003) and Walsh (Melbourne Royal Botanic Gardens, *pers. comm.*, 2003) provided a list of 40 species associated with gypsum sites in southeast Australia. Only seven of these have been recorded during this study so far, however a further 66 gypsum associated species were found. Eight new populations of *K suaedifolia* were discovered within the undisturbed sites at the Scotia Discharge Complex. No further records of *K. suaedifolia* were discovered at the disturbed sites.

Table 1. Preliminary list of South Eastern Australian gypsophiles 2003

Species	Source (2003)	This study	Preliminary list of SE gypsophiles	Source (2003)	This study
Poaceae			**Chenopodiaceae cont.**		
Austrostipa geoffreyi	DS	?	*Maireana appressa*	NW	
Austrostipa nulla nulla	DS,NW	?	*Maireana fimbriolata*	RP	
Poa fax	NW		*Maireana oppositifolia*	NW	
Azioacceae			*Osteocarpum acropterum*	NW	✓
Dysphania simulans	NW		*Sclerolaena symoniana*	DS	
Asteraceae			**Fabaceae**		
Brachyscome ciliocarpa	NW		*Swainsona minutiflora*	DS	
Brachyscome exilis	NW		*Swainsona phacoides*	NW	
Elachanthus glaber	NW		*Swainsona purpurea*	NW	
Elachanthus pusillus	NW		**Frankeniaceae**		
Eriochlamys behrii	NW		*Frankenia foliosa*	NW	✓
Haegiela tatei	NW		*Frankenia sessilis*	DS	
Kippistia suaedifolia	DS, NW,RP	✓	**Goodeniaceae**		
Minuria gardneri	DS		*Goodenia cenfracta*	DS	
Minuria multiseta	DS		*Goodenia gypsicola*	DS	
Othonna gypsicola	DS		*Scaevola collaris*	RP.	
Trichanthodium baracchianum	NW		**Malvaceae**		
Trichanthodium skirrophorum	NW		*Lawrencia helmsii*	DS, RP	

Boraginaceae			*Radyera farragei*	NW	
Embadium johnstonii	DS		**Myrtaceae**		
Brassicaceae			*Calytrix gypsophila*	DS	
Hymenolobus procumbens	NW		**Solanaceae**		
Campanulaceae			*Nicotiana burbidgeae*	DS	
Isotoma scapigera	DS		**Nicotiana glauca*	RP.	✓
Chenopodiaceae			*Nicotiana truncata*	DS	
Atriplex papillata	NW		**Zygophyllaceae**		
Halosarcia flabelliformis	NW		*Zygophyllum aurantiacum*	NW,RP	✓
Halosarcia halocnemoides	NW	✓	*Zygophyllum compressum*	NW,RP	
Halosarcia indica	NW	✓			

A total of 73 species from 28 families were identified during this survey (Table 2). The highest representation was from the Chenopodiacae and Asteraceae with 20 and 12 species respectively. Of the 73 species, 46 were found at the disturbed sites while 36 species were recorded in the undisturbed sites. The twelve exotic species from the mine sites reflect the high level of disturbance. Many of these exotic species are regarded as generalists, coping with a wide range of substrates. No exotic species were recorded from the Scotia sites. Only seven species were common between the sites, *Kippistia suaedifolia, Atriplex sp.2, Maireana pyramidata, Salsola kali, Sclerolaena muricata S. patenticuspis* and *Zygophyllum aurantiacum.* The majority of species were perennial with the exotic species influencing the number of annuals at the disturbed sites. Overall there were three trees, 27 perennial shrubs, six perennial low shrubs, 16 perennial forbs, one perennial vine, 20 annual forbs and three annual/biennial forbs.

Table 2. Comparison of species presence in Disturbed (Ds) and Undisturbed (Uds) gypsum sites 2003/04

Species	Life-form	Ds	Uds	Species	Life-form	Ds	Uds
Monocots				*Osteocarpum acropterum*	Pl	✓	
Liliaceae				*Rhagodia spinescens*	PS		✓
**Asphodelus fistulosus*	PF	✓		**Salsola kali*	A/B S	✓	✓
Poaceae				*Sclerolaena bicornis*	PS	✓	
Austrostipa sp.1	PF	✓		*Sclerolaena muricata*	PS	✓	✓
Austrostipa sp.2	AF		✓	*Sclerolaena parviflora*	PS		✓
Avena sp.	AF	✓		*Sclerolaena patenticuspis*	Pl	✓	✓
Bromus sp.	AF	✓		*Sclerolaena* sp.1.	Pl	✓	
Eragrostis sp.1. *(dielsii?)*	PF?	✓		**Convulvulaceae**			
Triodia scariosa	PF		✓	*Convolvulus erubescens*	PF	✓	
Dicots				**Cucurbitaceae**			
Asteraceae				**Citrullus colocynthis*	PV	✓	
Gnephosis tenuissima	AF		✓	**Euphorbiaceae**			
Brachyscome ciliaris	PF		✓	*Euphorbia drummondii*	F	✓	
Brachyscome sp.1.	AF?	✓		**Frankeniaceae**			
**Carthamus lanatus*	AF	✓		*Frankenia foliosa*	PS		✓
Centipeda cunninghamii	PF	✓		**Gentianaceae**			
**Chondrilla juncea*	AF	✓		*Centaurium tenuiflorum*	F	✓	
Kippistia suaedifolia	Pl	✓	✓	**Goodeniaceae**			
Olearia muelleri	PS		✓	*Goodenia cycloptera*	PF	✓	
Olearia pimeleoides	PS		✓	**Lamiaceae**			
Podolepis capillaris	AF		✓	**Marrubium vulgare*	PF	✓	
Pseudognaphalium luteo-album	AF	✓		**Salvia verbenaca*	PF	✓	
**Xanthium spinosum*	AF	✓		*Teucrium racemosum*	PF	✓	
Aizoaceae				*Westringia rigida*	PS		✓
Disphyma crassifolium subsp. clavellatum	PF		✓	**Malvaceae**			
Boraginaceae				*Sida* sp.	PS	✓	
**Echium plantagineum*	AF	✓		**Mimosaceae**			
**Heliotropium europaeum*	AF	✓		*Acacia burkittii*	PS		✓
Brassicaceae				**Myoporaceae**			
**Carrichtera annua*	AF	✓		*Eremophila glabra*	PS		✓
Menkea australis	F		✓	*Eremophila scoparia*	PS		✓
Sisymbrium sp.1	A/B	✓		*Eremophila sturtii*	PS		✓
Caesalpiniaceae				*Myoporum platycarpum*	T		✓
Senna artemisioides subsp. filifolia	PS		✓	**Myrtaceae**			
Campanulaceae				*Eucalyptus populnea*	T	✓	
Wahlenbergia communis	PF	✓		*Eucalyptus gracilis*	T		✓
Caryophyllaceae				**Nyctaginaceae**			

Species	Life-form	Ds	Uds	Species	Life-form	Ds	Uds
Spergularia rubra	A/BF		✓	*Boerhavia diffusa*	PF	✓	
Chenopodiaceae				**Proteaceae**			
Atriplex sp.1.	PS	✓		*Hakea leucoptera*	PS		✓
Atriplex sp.2.	PS	✓	✓	**Sapindaceae**			
Atriplex vesicaria	PS		✓	*Dodonaea viscosa* subsp. *angustissima*	PS		✓
Dissocarpus paradoxus	Pl	✓		**Scrophulariaceae**			
Enchylaena tomentosa	PS	✓		*Stemodia florulenta*	PF	✓	
Halosarcia halocnemoides	Pl		✓	**Solanaceae**			
subsp. halocnemoides				**Nicotiana glauca*	PS	✓	
Halosarcia helmsii	PS		✓	**Thymelaeaceae**			
Halosarcia indica	PS		✓	*Pimelea trichostachya*	F	✓	
Maireana brevifolia	PS	✓		**Zygophyllaceae**			
Maireana pentatropis	PF		✓	*Zygophyllum aurantiacum*	PS	✓	✓
Maireana pyramidata	PS	✓	✓	***Zygophyllum eremaeum***	PS/S		✓

*=exotic species, P=perennial, A=annual, F=forb, S=shrub, l=low shrub, T=tree, B=biennial, V=vine

DISCUSSION

The differences between previous records (Table 1) and the species recorded at this stage of the study (Table 2) highlight the paucity of study to date. Further investigations will enable the separation of species into obligate and facultative gypsophiles. The exotic species recorded, perhaps with the exception of *Nicotiana glauca* (Solanaceae), should be considered generalists. Both seasonal and regional differences will account for some discrepancy between the two lists but this should be negated as further sites are surveyed in NSW, NW Victoria and SA over a range of seasons. Species composition varied not only between the disturbed and undisturbed sites but also between natural populations occurring in different areas within the Scotia Discharge area. The composition of these sites reflect, to some degree, the surrounding communities and suggests that species are able to successfully migrate from their 'comfort zone' to the harsher gypsum environment. It is also likely that some perennial species with an extensive root system actually 'avoid' the gypsum. The influence of the location of gypsum in the soil profile, the purity and type of gypsum deposit on species composition will be investigated during the course of this research. This may help explain why *K. suaedifolia* is abundant at two of the mine sites surveyed but not located at others, which mining reports suggest are of 'poorer' gypsum content. This situation was replicated at the undisturbed situations in the Scotia Discharge Complex area, where *K. suaedifolia* grew abundantly on some gypsum islands, was absent from neighbouring gypsum islands, but was present on gypsum deposits some 20 km away.

ADAPTATION OF PLANTS TO GYPSOPHILOUS SOILS

The ecology of *K. suaedifolia* will form a major component of this study, including its reproductive ecology, ability to grow on other soils and establishment and growth characteristics. Seed has been collected from *K. suaedifolia* over the past two years and will be used along with that from other gypsophiles in seed germination trials. These trials will investigate the growth of key species in different purity levels of gypsum. Seed production, longevity, dispersal, germination and time to flowering will be studied in conjunction with anatomical and physiological adaptations. The soil seed bank will also be investigated at each site to determine: (i) seasonal differences in species composition, (ii) the presence of species that are unable to germinate or establish due to the gypsum substrate and (iii) the seed store of *K. suaedifolia.* The path of sulphur within *K. suaedifolia* and *Z. aurantiacum* will be traced using a scanning electronic microscope.

ACKNOWLEDGEMENTS

We greatly thank David Symon, SA Herbarium, John Pickard, Macquarie University, Peter Milthorpe, NSW DLWC Conodobolin, Bob Parsons, La Trobe University, Roy Kennedy, Ivanhoe, Paul Jaskiernak and Karen for their valued assistance. Financial support for this research was provided by

the Commonwealth Government Australia.

REFERENCES

Mattiske Consulting (1995). *Review of Botanical Values on a Range of Gypsum Dunes in the Wheatbelt of Western Australia.* Department of Conservation and Land Management, Western Australia.

Parsons, R.F. (1976). Gypsophily in plants - a review. *American Midland Naturalist* 96: 1-20.

Westbrooke, M.E, Miller, J.D. and Kerr, M.K.C. (1998). The vegetation of the Scotia 1: 100 000 map sheet, western New South Wales. *Cunninghamia* 5: 665-678.

RANGELAND MONITORING WITH MODIS 250M DATA

K. Richardson

Department of Infrastructure, Planning and Environment (DIPE), PO Box 30, Palmerston, NT 0831

ABSTRACT

Satellite based monitoring techniques have been developed and utilised extensively throughout the rangelands of Australia. This study evaluates the capability of 250m MODIS visible red band data for monitoring changes in vegetation cover upon north Australian rangelands.

Initial results indicate that MODIS data are able to track changes in rangeland vegetation upon red and black soil landscapes. The visible red band proved to be effective in monitoring changes of vegetation cover levels over a 12-month temporal sequence.

INTRODUCTION

The management of rangelands is very diverse and complex. Vastness, sparse populations and harsh conditions are major factors that contribute to the lack of data and information, which consequently affects the monitoring of rangeland condition. Rangeland monitoring based on satellite imagery has been identified as an important tool to assess conditions and landscape processes of rangelands (Pickup *et al.* 1993, Bastin *et al.* 1998).

Within the Northern Territory, satellite based monitoring techniques are being used to assess the conditions of rangeland utilised by the pastoral industry in the Victoria River District (VRD) and Sturt Plateau regions. Landsat Multi Spectral Scanner (MSS) and Thematic Mapper (TM) data are combined with ground based data to provide information on landscape cover change and processes. Current techniques provide monitoring information between years, at the end of the growing season. For improved commercial and sustainable management decisions, information is required throughout the year, when management decisions can be altered to suit current conditions.

A new generation satellite, Moderate-resolution Imaging Spectro-radiometer (MODIS) offers a possible solution, with increased spectral and temporal capabilities, to provide real time monitoring within a season. A Tropical Savanna CRC funded project aims to evaluate the capabilities of 250m MODIS visible red and near-infra-red (NIR) band data for mapping changes to rangeland condition in the VRD, NT for 2003 to 2004.

This paper evaluates the capabilities of 250m MODIS visible red band data for monitoring changes in vegetation cover throughout north Australian rangelands.

METHODS

The methods used for the project involve the integration of ground data with MODIS satellite imagery. It is a progressive application of techniques and methods developed and used for the satellite-based rangeland-monitoring program implemented within the Northern Territory (Wallace *et al.* 1994, Tongway and Hindley 1995, Karfs *et al.* 2000, Furby and Campbell 2001).

Study Area

Victoria River Downs is one of the oldest properties in the Victoria River District. The VRD region and Victoria River Downs have been the centre of many rangeland studies resulting in 'data rich' areas with extensive vegetation, soil, land resource and cattle production data available.

Data

Fortnightly acquisitions of cloud free 250m MODIS data from January 2003 to January 2004 were used. This included the visible-red band (B1) and the near-infra-red band (B2). Imagery was sourced from the TERRA satellite to provide consistency with departmental Landsat datasets. For the months of the wet season only a monthly image was selected due to the weather conditions and high levels of cloud cover experienced during this time. During December 2003 the TERRA satellite was not operational thus no data were acquired in this month. Imagery was supplied by the Western Australian Department of Land Information (DLI) following geometric, radiometric and atmospheric correction.

Site data utilised consisted of field observations, permanent monitoring sites and local knowledge from pastoralists. To provide consistency between the different types of site data, classification of the sites was necessary. The presence/absence of perennial grass species was used to separate sites into good and poor condition classes. This is consistent with the Landscape Function Analysis (LFA) approach of Tongway and Hindley (1995). Thus, poor sites will have very few to no perennial grass species, while a good site will be dominated by perennial grass species.

Due to the resolution of satellite imagery, 250m pixels, it was necessary to select homogeneous sites with a minimum size of 250m. As a consequence, the majority of poor sites were located at or near bores, while good sites were located at some distance from watering points. For the analysis of red soils, a total of 16 sites was selected across the property – eight representing areas of good condition and eight representing poor condition. For the black soils 24 sites were selected, 12 each for good and poor condition areas. A higher number were selected for the black soils as it makes up a larger proportion of the property.

Stratification is an important step when assessing satellite data for rangeland monitoring and validation with ground data (Graetz 1987, Friedel *et al.* 1993, Pickup *et al.* 2000). The site data were stratified between two pastorally significant landtypes upon the property – the limestone-calcareous red soils and the basaltic-derived black soils. Stratification was based on 1:100,000 landunit mapping of the property (McLeod and VanCuylenburg, in prep).

The mean values for the red and black soil landtypes were calculated within ERMapper in the red band (B1) and near-infra-red band (NIR) (B2). Mean values were also calculated for the sites and plotted.

RESULTS AND DISCUSSION

Initial results indicate that differences between areas of good and poor condition can be detected using MODIS 250m data. Of the 16 sites analysed for red soils and 24 for black soils, an average was calculated and used to plot good and poor areas on the time traces shown in Figure 1 and Figure 2.

From the time traces, differences between good and poor condition areas can be detected for each landtype. Differences in the time traces of the sites represent changes in cover levels, which become apparent towards the end of the dry season. NIR band data were also assessed but differences were less apparent in red soil compared with black soil landtypes. As a result further analysis with be performed upon this band.

Time traces of the landtypes and sites over a dry-wet season sequence highlight the complexities of monitoring vegetation cover in north Australia. During the wet season, January to April, vegetation cover is very high and green. Discriminating between areas of poor and good condition is very difficult due to high cover levels across the region. As the pastures begin to hay off and lose moisture content (greenness) differences between the sites become apparent.

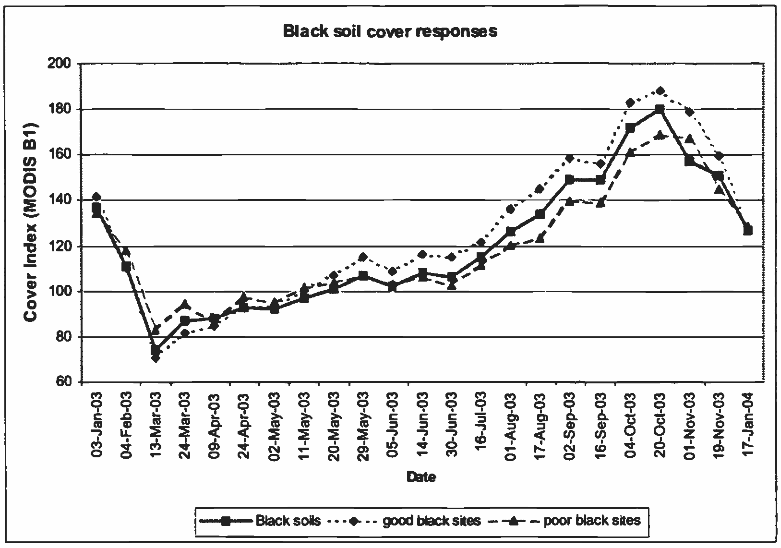


Figure 1. Time trace of the black soil landtype with poor and good sites. Discrimination between good and poor sites during the wet season is difficult due to high levels of green cover. As the dry season prevails and vegetation cover loses moisture content, differences between poor and good sites become apparent.

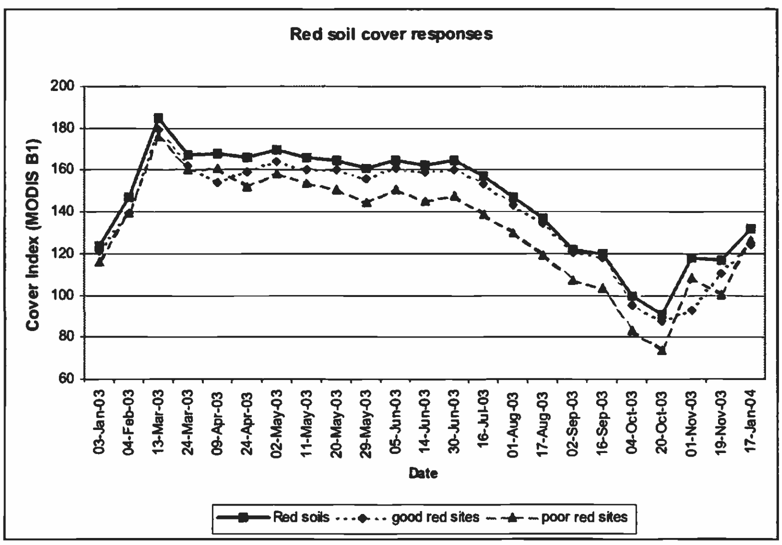


Figure 2. Time trace of red soil landtype with poor and good sites. Discrimination between good and poor sites during the wet season is difficult die to high levels of green cover. Separation between sites of varying condition is detectable as vegetation cover begins to hay off.

A *t*-test was performed upon the means of the samples from each set of sites for each date of MODIS imagery for the red band. It was found that good and poor sites were significantly different at the 0.05 significance level for half of the dates of the MODIS imagery.

For red soil sites these differences occurred earlier in the dry season than the black soil sites and ended earlier than the black soil types. This information can be used to assess the condition of areas throughout the season.

CONCLUSION

The project demonstrated that vegetation cover levels are able to be monitored using 250m MODIS data. Differences in condition could be detected upon red and black soil landtypes. Red band data were found to be effective in detecting changes in vegetation cover levels. Further advancement and application of 250m MODIS data would include extrapolating MODIS imagery to the wider VRD region and assessing other significant landtypes throughout the district.

REFERENCES

Bastin, G.N., Chewings, V.H. and Pearce, G. (1998). Verifying high-resolution satellite data using aerial videography. Ninth Australasian Remote Sensing Conference Proceedings. Sydney (on CD-ROM).

Friedel, M.H., Pickup, G. and Nelson, D.J. (1993). The interpretation of vegetation change in a spatially and temporally diverse arid Australian landscape. *J. Arid Environments* 24: 241-260.

Furby, S.L and Campbell, N.A. (2001). Calibrating images from different dates to 'like-value' digital counts. *Remote Sensing of Environment* 77: 186-196.

Graetz, R.D. (1987). Satellite remote sensing of Australian rangelands. *Remote Sensing of Environment* 23: 313-331.

Karfs, R., Applegate, R., Fisher, R., Lynch, D., Mullin, D., Novelly, P., Peel, L., Richardson, K., Thomas, P. and Wallace, J. (2000). Regional land condition and trend assessment in tropical savannas: The Audit Rangeland Implementation Project Final Report. National Land and Water Resources Audit, Canberra.

McLeod, P.J. and VanCuylenburg, H.R.M. (in prep.). *Land Resources of the Victoria River District.* Resource Capability Assessment Branch, Department of Infrastructure Planning and Environment, NT.

Pickup, G., Bastin, G.N. and Chewings, V.H. (2000). Measuring rangeland vegetation with high resolution airborne videography in the blue-near infrared spectral region. *International Journal of Remote Sensing* 21: 339-351.

Pickup, G., Chewings, V.H. and Nelson, D.J. (1993). Estimating changes in vegetation cover over time in arid rangelands using Landsat MSS data. *Remote Sensing of Environment* 43: 243-263.

Tongway, D. and Hindley, N. (1995). *Manual for Assessment of Soil Condition of Tropical Grasslands*. CSIRO, Division of Wildlife and Ecology, Canberra, Australia.

Wallace, J.F., Holm, A.McR., Novelly, P.E. and Campbell, N.A. (1994). Rangeland monitoring and change detection using remote sensing. National Landcare Program Project 91/W/M5 Final Report. CSIRO Division of Mathematics and Statistics, Agriculture Western Australia.

WHAT'S IN A PHOTOGRAPH? A COMPARISON OF PHOTOGRAPHIC AND FIELD MEASUREMENT TECHNIQUES FOR MONITORING SITES IN THE SOUTHERN RANGELANDS OF WESTERN AUSTRALIA

Peter J. Russell

CMAE, Curtin University of Technology, Locked Bag 22, Kalgoorlie WA 6433

ABSTRACT

This ongoing study is examining the efficacy of using photographic interpretation to derive selected landscape function indices, as part of a larger study of rangeland ecological health. The internal representativeness of 12 Western Australian Rangeland Monitoring System (WARMS) monitoring sites, located on a variety of land systems, was examined by comparing the same indices acquired by three different, quadrat-based, methods: (1) routine transect field measurement, (2) photosite field measurement, and (3) photosite photo-interpretation. Correlation and regression analyses reveal that Soil Surface Condition (SSC) indices (soil stability, water infiltration, nutrient cycling) have very strong associations between the three methods. Based on this study, photo-interpretation can effectively derive robust and consistent SSC indices, and although not yet able to infer results of a physical soil test such as slake, have wide application in landscape and catchment function mapping and monitoring, in conjunction with field programmes.

INTRODUCTION

This study is examining the efficacy of using photographic interpretation techniques to derive selected landscape function indices. It is part of a larger project concerned with producing regional scale interpretations of changes in the ecological health of the southern rangelands of Western Australia over the last three decades or so. These changes, to be mapped in space and time, are being derived from an analysis of historical and contemporary data held by the Western Australian Department of Agriculture in its WARMS (Western Australian Rangeland Monitoring System) database. WARMS is designed to provide data on rangeland condition by monitoring the long-term status of perennial plants and soil surfaces. For the southern rangelands, each monitoring site (Fig. 1) consists of a trapezoid-shaped photosite (121 sq m), and three contiguous, parallel belt transects (each 60 to 400 sq m). There are 996 current, permanently marked, shrubland sites, and many more old WARMS and Pastoralist Monitoring Sites (PMS). All data, apart from NDVI (Normalised Difference Vegetation Index), are acquired by field measurement in a five-year reassessment cycle. Transect data collected include plant species and metrics (height, maximum width, location), and a suite of attributes for Landscape Function Analysis (LFA) and Soil Surface Condition (SSC) assessment. On the adjoining photosite, a plant count by species is done, and a single low-angle oblique photograph is taken from a set position.

To date, photographs have been used by pastoralists and Department of Agriculture staff, only as a visual record of local range condition. Showing changes through time at approximately five-year intervals, these photographs are a very valuable but presently under-utilised resource. It is an aim of this study to develop techniques to extract three-dimensional (3-D) plant metrics and soil surface condition (SSC) attributes from repeat 2-D photographs so as to be able to calculate certain indices of ecological health. For a recent review of the use of repeat photography in landscape studies, see Pickard (2002). Work on the SSC aspects is essentially complete and is outlined here but work on the 3-D aspects is still in progress (companion study for doctoral thesis).

METHODS

Given that the overarching ecological health project relies, in part, on the interpretation of historical monitoring site photographs, a critical aspect is to establish that data collected from a photosite, whether through field measurement or photo-interpretation, are a good analogue of the transect data. In other words, do the photosite and associated transects tell the same story? This concern applies equally to the SSC data (discussed here) and the plant data (companion study).

The internal consistency of the 12 WARMS sites selected for this orientation study (Table 1), is examined by comparing the same SSC indices acquired by three different, quadrat-based, methods: (1) routine transect field measurement, (2) photosite field measurement, and (3) photosite 2-D photo-interpretation. The SSC indices are soil stability, water infiltration and nutrient cycling (Tongway, 1994), calculated from the following suite of soil surface attributes: soil cover (rain interception), soil cover (surface flow interception), crust broken-ness, cryptogam cover, erosion type and severity, extent of deposited material, litter cover, surface microtopography, surface nature, texture and slake. These attributes are fully described by Tongway (1994).

Table 1. WARMS orientation study sites and land systems – Southern Rangelands.

SITE NO	*REGION*	*LAND SYSTEM **
WIL_009	Carnarvon	**Phillips:** stony rounded hills, uplands, lower interfluves & gently sloping drainage flats over granite/gneiss/dolerite: acacia & chenopod shrubland.
WIL_017	Carnarvon	**Jimba:** gently sloping alluvial plains on Permian sedimentary rocks, occas. stony plains & low rises, chenopod & patchy acacia shrubland.
WIL_028	Carnarvon	**Durlacher:** stony flat plains, low rounded hills & upper interfluves over granite/gneiss; acacia & chenopod shrubland & low woodland.
NAM_018	Meekatharra	**Carnegie:** saltlakes, saline flats, sandy banks, halophytic shrubland.
NAM_030	Meekatharra	**Gransal:** stony plains & low rises on granite, halophytic shrubland.
YAN_082	Meekatharra	**Darlot:** saltlakes, saline alluvial plains, sandy banks, claypans, halophytic shrubs, spinifex & wanderrie grassland.
GUN_002	Nullarbor	**Gunnadorah:** flat, smooth clay & kankar plains, some 'dongas' (drainage foci) & claypans, over Nullarbor Limestone; sparsely wooded bluebush shrubland.
KIN_002	Nullarbor	*Not yet mapped*
NTS_133	Nullarbor	*Not yet mapped*
PON_162	Nullarbor	*Not yet mapped*
RAW_109	Nullarbor	*Not yet mapped*
VIG_004	Nullarbor	*Not yet mapped*

* Land system descriptions summarised from inventory and condition survey reports by Pringle *et al.* (1994), Curry *et al.* (1994), Payne *et al.* (1980), and Mitchell *et al.* (1988).

The orientation study sites represent a wide variety of land systems and soil conditions.

Routine transect field measurement

Landscape function analysis (LFA), including SSC field assessment techniques, are comprehensively described in Tongway (1994) (the "brown manual") and the latest revision (Tongway, in press). On WARMS transects, the 11 SSC attributes are assessed for each of 20 x 1 sq m quadrats, and the patch type (shrub or inter-shrub) within which each quadrat occurs, is also noted. The quadrats are not photographed. The SSC analysis spreadsheet (to calculate the SSC indices) allows input of up to six quadrats for each patch type. In practice, this study found that the total number of quadrats used in analysis ranged from six to ten for each monitoring site transect. For those patch types with more than six quadrats, six quadrats are randomly selected.

Photosite field measurement

Within the photosites, 5 x 1 sq m quadrats were utilised. For all 12 sites, the set of quadrats was positioned so as to 'capture' the complete range of soil conditions based on a brief inspection of the site. This layout format is termed 'selected-position' and, obviously, the layout was different for each site. For the six Nullarbor sites only, a second format was incorporated into the study. This additional format, termed 'fixed-pattern', was designed to preclude potential operator bias in the SSC data collection, by sampling the site according to a fixed quadrat pattern (Fig. 1), irrespective of the distribution of soil condition classes.

All quadrats were digitally photographed prior to field assessment, so as to record minimally disturbed soil surfaces, with the camera (wide-angle setting) held by hand approximately 1.45 m above one edge of the quadrat. Infrequently, a bushy shrub partially obscured the soil surface, in which case, a second photograph was taken from a different position to supplement the first.

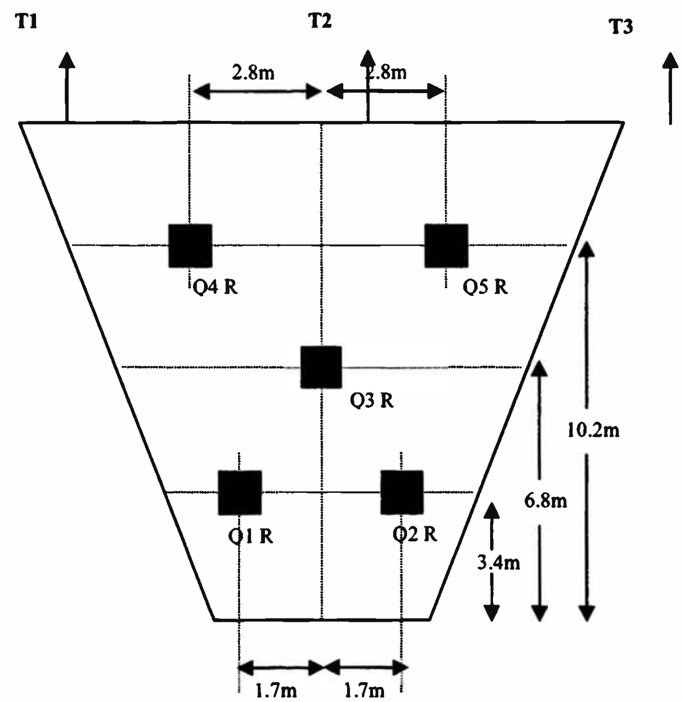


Figure 1. WARMS photosite 'fixed-pattern' layout of 5 x 1 sq m SSC quadrats.

Field assessment of the SSC attributes was undertaken on each of the quadrats (both formats for Nullarbor sites) using the standard transect procedure, and the data used to calculate the SSC indices, using the same spreadsheet analysis as used for the transect quadrats.

Photosite photo-interpretation

Quadrat photographs were downloaded as jpeg files to a laptop and displayed using MS Photo Editor. This software provides basic functions such as colour balance adjustment and zoom in/out. Photo-interpretation of quadrats was undertaken by the author many days or weeks after the field assessments, to minimise 'retained memory' effects, and in randomised order from the sites.

Interpretation consisted of making a judgement on the appropriate value or class for each of the SSC attributes except 'slake'. Slake is the only attribute which was not interpreted from the photographs; its value obtained from the WARMS database from previous field measurement. All photosite quadrats were photo-interpreted and used in the calculation of the SSC indices, using the same spreadsheet analysis as used for the field-assessed transect and photosite quadrats.

RESULTS

All photosite and transect SSC indices for the 12 orientation study sites are tabulated in the Appendix (Table 3). The transect data are considered to be the reference set (the 'independent variable') by which the photosite data ('dependent variables') are compared. Results of correlation and regression analysis of the indices are presented in Table 2 and Figure 2, respectively.

Table 2. Combined SSC Indices – Pearson rank correlation coefficients (r) matrix.

	Tr-FM	*Ph-SP-FM*	*Ph-SP-PI*	*Ph-FP-FM*
Ph-SP-FM	0.958			
Ph-SP-PI	0.952	0.987		
Ph-FP-FM	0.920	0.987	0.987	
Ph-FP-PI	0.943	0.985	0.993	0.990

Abbreviations: Tr transect, Ph photosite, FM field measured, PI photo-interpreted, SP selected-position (quadrat layout), F-P fixed-pattern (quadrat layout).

Analyses of the combined SSC indices show very strong correlation ($r > 0.920$) between photosite and associated transect indices, irrespective of assessment method (field or photo-interpretation) and quadrat layout format (selected-position or fixed-pattern). Within photosites, SSC correlations are similarly very strong ($r > 0.987$), exemplified by the selected-position and fixed-pattern formats, irrespective of assessment method (field or photo-interpretation).

The regression analysis (Fig. 2) supports the strong associations established by correlation analysis. For each of the four treatments (Fig. 2; (a) - (d)), the slope of the regression line is 1.00 ± 0.06, indicating a 1:1 direct relationship between transect and photosite measured SSC indices. Regression shows no significant difference in the photosite SSC values collected by field measurement or by photo-interpretation, using both quadrat layouts, compared with transect SSC values. The indices from all sites, except one (KIN_002, labelled on Fig. 2), fall within the 90% prediction envelope and most fall within the 90% confidence envelope.

DISCUSSION

This study has shown that SSC data collected from the photosite are directly comparable with data collected from their associated transect. With few exceptions, the photosite is representative of the monitoring site as a whole. Within the photosites, no sampling format (selected-position or fixed-pattern) or data acquisition method (field or photo-interpretation) is clearly superior or inferior with respect to data quality.

Contrary to expectations, given the different aggregate sample sizes, the range in values of the SSC indices captured within photosites is similar to the range captured by transects. From this, an initial conclusion is that the transects, in many cases, sample more than is necessary in order to derive representative SSC indices. However, an example that does not support this conclusion is site KIN_002, which plots well outside the 90% regression envelopes. It is an excellent example of the sensitivity of the SSC indices to detecting and quantifying landscape heterogeneities. Perusal of the SSC indices for this site (Table 3, particularly water infiltration) shows a large difference between the transect and photosite values. This is not an error in data collection; rather, the values reflect very marked heterogeneity across the monitoring site with the photosite occurring almost entirely beneath two large Western myall (*Acacia papryocarpa)* trees forming a patch zone with good litter cover whilst the transects run entirely across a wide interpatch zone with minimal litter cover. Other sites such as WIL_028 and NTS_133 (Table 3) also show some intra-site heterogeneity, but not as distinctly as KIN_002.

Overall however, the WARMS sites show a low amount of intra-site heterogeneity indicating that most are tightly located in relatively homogeneous portions or components within spatially organised landscapes. In conclusion, this study has shown that the interpretation of 2-D photographs of soil surfaces can produce reliable and consistent SSC indices, which may then be used as one measure of landscape health. The photo-interpreter does need to have field experience in assessing soil surfaces, and regardless of whether correct values for the slake test can be consistently inferred from photographs, there will always be a need for a field component to supplement and 'ground truth' any programme of photo-interpretation.

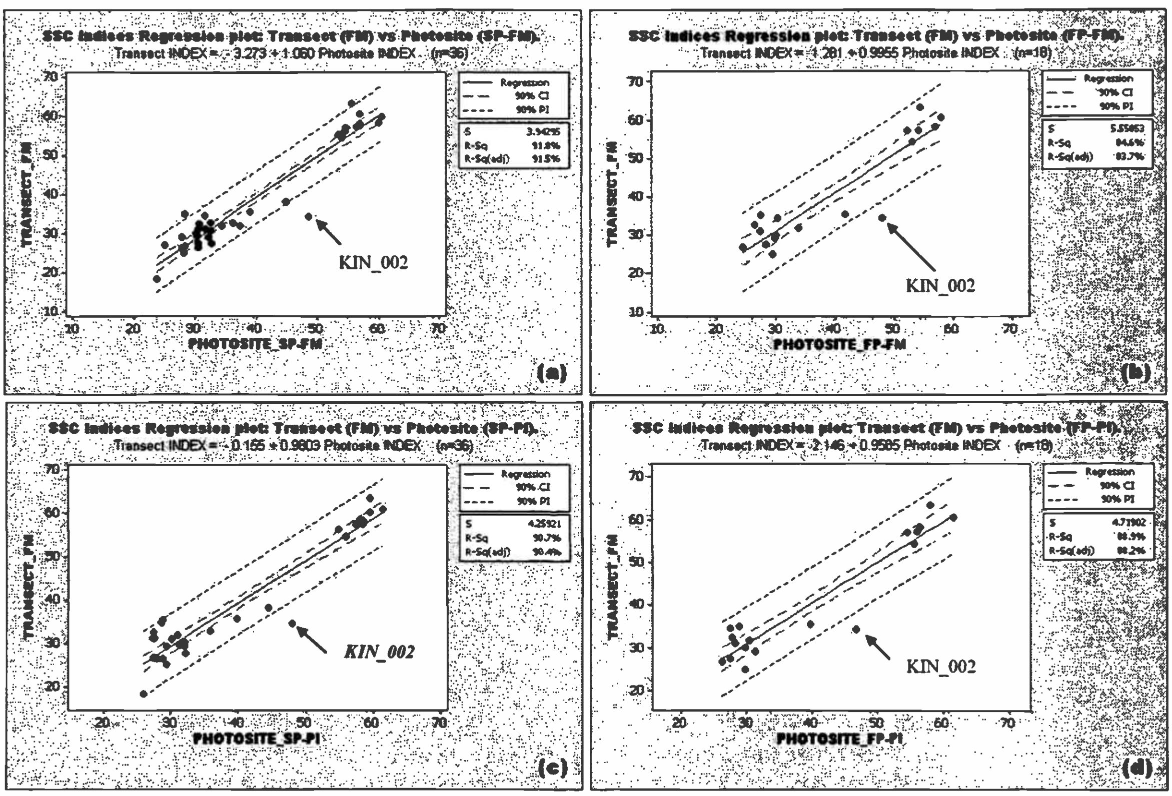


Figure 2. Linear regression plots of combined Soil Surface Condition (SSC) indices. Transect field measured (FM) indices are plotted against photosite indices derived from (a) selected-position (SP), field measured (FM) quadrats, (b) fixed-pattern (FP), field measured (FM) quadrats, (c) selected-position (SP), photo-interpreted (PI) quadrats, and (d) fixed-pattern (FP), photo-interpreted (PI) quadrats. 90% confidence and prediction intervals are shown.

ACKNOWLEDGEMENTS

I wish to sincerely thank Wayne Fletcher for his extensive assistance on WARMS field trips in 2003 and early 2004. My supervisors, Drs Ben Norton and Ian Watson, provided valuable guidance during data acquisition and analysis, and during preparation of this paper, for which I sincerely thank them. Hugh Pringle also provided useful feedback, for which I am appreciative. I am also grateful to Phil Thomas for his continued help in use of the WARMS database and to David Tongway for advice and use of his LFA workbook.

REFERENCES

Curry, P.J., *et al.* (1994). An Inventory and condition survey of rangelands in the Murchison River catchment and surrounds, Western Australia. Tech. Bull. No. 4, Dept of Agriculture, WA. 430 pp.

Mitchell, A.A., *et al.* (1988). A range inventory and condition survey of part of the Western Nullarbor Plain, 1974. Perth, Dept of Agriculture, WA. 141 pp.

Payne, A.L., *et al.* (1980). An Inventory and condition survey of rangelands in the Carnarvon Basin, Western Australia. WA Dept of Agriculture Tech. Bull. No 73. 478 pp.

Pickard, J. (2002). Assessing vegetation change over a century using repeat photography. Aust. J. Bot. 50: 409-414.

Pringle, H.J.R., *et al.* (1994). An Inventory and condition survey of the north-eastern Goldfields, Western Australia. Dept of Agriculture, WA. 322 pp.

Tongway, D. (1994). Rangeland Soil Condition Assessment Manual. CSIRO Division of Wildlife & Ecology, Canberra ACT. 69 pp.

APPENDIX

Table 3. Abridged table of Soil Surface Condition (SSC) results.

WARMS SITE No	TRANSECT FIELD INDEX (%)	TRANSECT FIELD Nº of QUADRATS	PHOTOSITE (5 Quadrats per site) SELECTED-POSITION QUADRATS FIELD INDEX (%)	SELECTED-POSITION QUADRATS PHOTO-INTERP INDEX (%)	FIXED-PATTERN QUADRATS FIELD INDEX (%)	FIXED-PATTERN QUADRATS PHOTO-INTERP INDEX (%)
SOIL STABILITY INDEX						
GUN_002	57.4	7	56.5	57.5	54.0	56.0
KIN_002	58.3	9	57.0	58.5	57.0	56.5
NAM_018	58.4	8	60.0	58.0	no data	no data
NAM_030	57.6	10	57.0	no data	no data	no data
NTS_133	63.4	10	55.6*	59.5*	54.4	58.0
PON_162	54.5	8	54.0	56.0	53.0	55.5*
RAW_109	60.7	7	57.0	61.5	58.0	61.5
VIG_004	57.2	8	54.6	58.5	52.2	54.5
WIL_009	60.1	6	60.5	59.5	no data	no data
WIL_017	56.1	8	54.5	55.0	no data	no data
WIL_028	38.0*	9	45.0	44.5	no data	no data
YAN_082	55.3	8	53.5*	no data	no data	no data
WATER INFILTRATION / RUNOFF INDEX						
GUN_002	31.8	7	34.4	30.9	33.7	30.4
KIN_002	34.3	9	48.5	48.1	47.9	46.7*
NAM_018	31.1	8	30.5	27.6	no data	no data
NAM_030	32.0	10	37.3*	no data	no data	no data
NTS_133	30.0	10	30.1	32.0*	29.8	29.7
PON_162	31.0	8	31.6*	27.2	27.2	28.3
RAW_109	24.9	7	28.2	29.3	29.3*	29.7
VIG_004	27.5	8	30.4	32.1	28.2	27.4
WIL_009	29.1	6	32.1	32.0	no data	no data
WIL_017	29.3	8	30.3	31.2	no data	no data
WIL_028	32.7	9	36.3	35.9	no data	no data
YAN_082	32.6	8	32.4	no data	no data	no data
NUTRIENT CYCLING INDEX						
GUN_002	34.5*	7	31.6	28.6	30.2	27.4
KIN_002	35.4	9	39.0	39.9	41.8	39.7*
NAM_018	26.3	8	27.9	27.9	no data	no data
NAM_030	27.5	10	32.6*	no data	no data	no data
NTS_133	35.1*	10	28.4	28.8*	27.4	28.8
PON_162	32.5	8	30.7	27.4	26.3	27.7
RAW_109	29.1	7	27.9	29.3	29.7*	31.3
VIG_004	26.7	8	28.4	27.4	24.3	26.4
WIL_009	26.4	6	30.5	28.8	no data	no data
WIL_017	30.7*	8	32.5	30.1	no data	no data
WIL_028	18.3*	9	23.7	25.9	no data	no data
YAN_082	27.1	8	25.1	no data	no data	no data

* Result for which the standard error (SE) exceeds by more than 1 standard deviation (SD), the mean SE calculated for each column of indices.

All field measurements done according to procedures described in Tongway (1994). Indices calculated using MS Excel workbook (vers. 2.2, 10 July 2001) kindly supplied by David Tongway (CSIRO, Canberra).

ABORIGINAL PERSPECTIVES ON THE KANGAROO INDUSTRY IN SOUTH AUSTRALIA: AN INTRODUCTION TO CURRENT RESEARCH

D.A. Thomsen

School of Earth and Environmental Sciences, The University of Adelaide,
Roseworthy campus, Roseworthy, SA 5371

ABSTRACT

Kangaroos are culturally significant to Aboriginal people but Aboriginal people are generally not involved in kangaroo management or in the commercial kangaroo industry. Our research has provided the first opportunity for Aboriginal people in South Australia to present their perspectives on the commercial harvest of kangaroos. We found a diverse range of views on this topic from Aboriginal research participants, but a commonality is the desire to be involved in decision-making processes for kangaroo management. The successful involvement of Aboriginal people in kangaroo management requires improved communication and greater understanding of cultural considerations and the diversity of Aboriginal perspectives.

INTRODUCTION

This paper introduces current research which is addressing a lack of understanding about social issues that influence the sustainable development of the commercial kangaroo industry. This research involves the examination of the kangaroo industry in terms of social and institutional factors that influence commercial harvest with the aim of improving understanding of the factors that act as constraints to industry development and limit the industry's ability to contribute to the economic viability of rural and remote communities. An outcome of this research will be recommendations for institutional and policy changes that deliver social and economic benefits to industry stakeholders and to rural communities.

An integral component of this research is the consideration of indigenous perspectives about the commercial harvest of kangaroos. These perspectives have not been previously researched nor considered in the management of the commercial harvest of kangaroos. Further, there are very few Aboriginal people involved in this industry and there are no mechanisms for the inclusion of indigenous people in decision-making processes for management. This is the case despite various agencies advocating indigenous involvement in the commercial harvest of kangaroos as a pathway for economic development (ATSIC and DPIE 1997).

The indigenous component of the research project is designed to produce recommendations for ethical and appropriate consideration of Aboriginal cultural knowledge and values associated with kangaroo harvesting, and improved capacity for equitable and appropriate Aboriginal involvement in the kangaroo industry through better understanding of indigenous aspirations and cultural considerations. This paper first provides some background to the commercial kangaroo industry and then summarises research findings about Aboriginal perspectives and issues regarding the commercial harvest of kangaroos.

BACKGROUND TO THE COMMERCIAL HARVEST OF KANGAROOS

The commercial kangaroo industry emerged as a pest control mechanism for rural communities in response to increased abundance of the larger species of kangaroos (e.g. red kangaroos, eastern and western grey kangaroos, and euros). In the past, the prolific explosion in populations of the larger species of kangaroos was often explained as the result of reducing dingo populations but, while dingo predation does impact on kangaroo density, current knowledge tells us that kangaroos were a beneficiary of landscape alteration caused by pastoralism. Landscape changes, such as the conversion of wooded areas to pasture and the provision of watering points for stock, and dingo control measures, such as the construction of the dingo fence and baiting activities, resulted in kangaroo overabundance and the labelling of the kangaroo as an agricultural pest (Pople and Grigg 1999).

Sustainable harvest of kangaroos is justified by the argument that large numbers of kangaroos cause problems for rangeland production and conservation values. Without a commercial kangaroo industry, pastoralists would still act to control kangaroo numbers, but there would be no monitoring mechanisms for the cull and the culled kangaroos would be wasted rather than utilised as a valuable resource. Also, some commentators suggest that in the absence of commercial harvest, pastoralists could opt for the cheapest and most effective means for reducing local kangaroo populations (such as poisoning water sources or non-professional shooting) which would not necessarily be the most humane or sustainable options (Pople and Grigg 1999).

Under current legislation, kangaroos are managed by the Crown and their harvest is controlled by state National Parks and Wildlife authorities through a quota system and the issue of tags to licensed shooters, landholders or meat processors. As state governments are primarily responsible for developing and implementing kangaroo management plans, the management of kangaroos varies to some extent from state to state. Despite some variance in approaches to management, in all states current kangaroo management plans emphasise conservation values and aim to maintain species across their ranges while reducing deleterious impacts on pastoral activities through sustainable harvest (Ramsay 1994).

ABORIGINAL PERSPECTIVES ABOUT THE COMMERCIAL HARVEST OF KANGAROOS

This research has explored the perspectives and aspirations of Aboriginal people in two cultural regions of South Australia, the Western Desert cultural region and the northern Flinders Ranges. Research methods were primarily qualitative involving consultations with authoritative Aboriginal people about their perspectives, aspirations and how they see their rights and interests in relation to the commercial harvest of kangaroos. This enquiry found that cultural protocols and other issues influence the engagement of Aboriginal people with the commercial kangaroo industry. However, there is not one perspective or view point that is common for all Aboriginal research participants. Rather, there is a range of indigenous views regarding the commercial kangaroo industry.

For some Aboriginal people, strict cultural protocols preclude any involvement in the commercial harvest, while for people from other regions, where the cultural laws concerning kangaroos are quite different, there is interest in developing businesses based on kangaroo harvest. Despite the diversity of views about commercial kangaroo harvest, Aboriginal people across South Australia highly value kangaroos and desire to be included in decision-making processes for kangaroo management.

Cultural considerations

Many Aboriginal people consider that eating kangaroo is important for their physical and cultural health. Kangaroo meat is known to be a lean and healthy product, but for some Aboriginal people the health benefits of kangaroo are also inextricably linked to the spiritual and cultural. The cultural protocols involved in the harvest, preparation, distribution and consumption of kangaroo vary according to the customary practices of particular language groups. While customary protocols differ across South Australia, the cooking of the entire carcass is a widespread preference. In some cultural regions of South Australia the customary protocols regarding kangaroo are strict and the consequences of not following customary protocols very serious. Thus, for some South Australian Aboriginal people, it is culturally inappropriate to purchase kangaroo meat that has been processed according to non-indigenous laws and practices.

As the cultural protocols of kangaroo harvest are not catered for by the commercial industry, it is important for Aboriginal people to be able to hunt kangaroos. In consultations with Aboriginal people during this research, issues of access to kangaroos were raised. We found that Aboriginal hunters may face difficulties accessing kangaroos due to regulatory requirements of gun ownership, economic considerations such as the cost of a vehicle, and difficult relationships with landholders may mean they do not feel secure and confident when hunting on pastoral leases. Problems such as these are impacting on the ability of Aboriginal people to access kangaroo meat.

During the course of this research project a proposal for the establishment of a unique indigenous business venture based on the harvest of kangaroos for the Aboriginal market in the Port Augusta region emerged. Unlike existing methods employed in the commercial harvest of kangaroos, this enterprise has been developed to take account of Aboriginal cultural values and protocols. While this business proposal fits poorly into the current institutions that govern commercial kangaroo harvest, the South Australian government has responded favourably to the proposal. Business planning and establishment is continuing with the prospect of starting to sell kangaroos to Port Augusta people early in the 2004/5 financial year. Further developments regarding this business venture will be reported on in due course.

Indigenous involvement in kangaroo management

The advice that the Aboriginal people consulted provided about addressing Aboriginal perspectives and interests in commercial kangaroo harvest is quite simple. Generally, people want the opportunity to discuss their views and issues about kangaroo management and have meaningful input into decision-making processes. The successful promotion of Aboriginal involvement in kangaroo management is dependent on effective communication and trusting relationships. While this research has found that these are not often present, capacity building approaches that aim to develop mutual understanding between Aboriginal people and other stakeholders in the kangaroo industry could redress the situation. The employment of Aboriginal people in kangaroo management programs and education programs for stakeholders are ways in which capacity for understanding may be improved.

CONCLUSION

This paper has provided a brief description of current research exploring social aspects of the commercial kangaroo industry with particular emphasis on the issues and perspectives that the industry presents for Aboriginal people. An important finding is that there is no one perspective on commercial kangaroo harvest common to all Aboriginal research participants. While cultural considerations influence the perspectives of Aboriginal people about the kangaroo industry, cultural protocols surrounding kangaroos vary between language groups. There is potential for the appropriate engagement of Aboriginal people in kangaroo management through greater understanding and respect for the diversity of indigenous culture and protocols regarding native wildlife.

ACKNOWLEDGEMENTS

My involvement in this research project is made possible only through the continuous support of the project supervisor, Dr Jocelyn Davies, and fellow researcher, Mr Kado Muir. This project has benefited greatly through the research assistance provided by Yami Lester and Luke Diddams. All the researchers involved are very grateful to the organisations that fund this project: Rural Industries

Research and Development Corporation, Australian Institute of Aboriginal and Torres Strait Islander Studies, Land and Water Australia and the South Australian Department for Environment and Heritage.

REFERENCES

ATSIC and DPIE (Aboriginal and Torres Strait Islander Commission and Department of Primary Industry and Energy) (1997). *National Aboriginal and Torres Strait Islander rural industry strategy.* ATSIC, Canberra.

Pople, T. and Grigg, G. (1999). *Overview of Background Information for Kangaroo Management: Commercial Harvesting of Kangaroos in Australia.* Report to Environment Australia, Version 99/1.

Ramsay, B.J. (1994). *Commercial use of wild animals in Australia.* Department of Primary Industry, Bureau of Resource Sciences and Australian Government Publishing Service, Canberra.

POSITIONING YOURSELF FOR A FUTURE IN THE RANGELANDS

John A. Taylor

Rangelands Australia, The University of Queensland's Gatton Campus, Gatton, Q 4343

ABSTRACT

This paper explores rural business conditions, change and work opportunities in related areas in Australia's rangelands, and highlights the qualities, skills and knowledge that are sought by employers and are perceived to be critical to success in the rangelands. The need for life-long learning is also highlighted, and some short and medium-term priorities for skill development in the rural industries are identified.

INTRODUCTION

Significant change is anticipated in the nature of enterprises and their operating environment in Australia's rangelands over the next 5-10 years (Taylor 2002). Increasing skills and knowledge through formal and informal education and training is a widely recognised and valued strategy for building capacity to manage change, and for positioning oneself for success in the future.

Taylor (2002) reports stakeholder perceptions of the personal qualities and knowledge required for success in the rangelands in 5-10 years time. Taylor (2003) has also identified skill and knowledge gaps among producers and agency staff that could potentially limit the capacity of these groups to respond to the likely changes and to position themselves for a strong future in the rangelands.

This paper explores some of the short- (i.e. next 12 months) to medium-term (i.e. 5-10 years) opportunities for people in the rangelands, and links these to the medium-term expectations of producers/managers and agency staff in particular. The paper uses preliminary data from a survey of business confidence and employment opportunities in Australia's rangelands. These data are based on a postal survey of over 150 producers (24% return rate) and a telephone survey of senior staff of primary industry and natural resource agencies (e.g., CALM WA, NSW DIPNR, NSW Agriculture, NT DBIRD, NT DIPE, PIRSA, SA DLWBC, QDPIF, QDNRM&E, WA Ag, WADE, etc.) and large pastoral companies (e.g. Australian Agricultural Company, Consolidated Pastoral, Colonial Agriculture, Heytesbury Beef, S. Kidman & Company, Stanbroke Pastoral Company, etc.).

BUSINESS CONFIDENCE

Almost all corporate rural enterprises (largely cattle or beef focused) considered business conditions to be 'strong' in the past 12 months, and expect business conditions to be 'somewhat stronger' in the next 12 months. This is consistent with Rabobank's recent (i.e. March 2004) and wider rural confidence survey that highlights beef as the most optimistic of all rural sectors (Rabobank 2004).

Of the family enterprises, business conditions in the past 12 months were mostly considered to be either 'strong' (50%) or 'weak/very weak' (36% respondents), with a small proportion (14%) believing that conditions were 'neutral'. Those who indicated that conditions had been 'weak/very weak' (i.e. all wool/sheep producers) expect business conditions to be about the same over the next 12 months. Those who thought that past conditions had been 'strong' (i.e. beef or mixed enterprises), expect business conditions in the next 12 months to be 'about the same' or 'stronger'.

However, this does not mean that one sector will face more problems than another, or that there will be few, if any problems. Almost all rangeland enterprises expect to face continuing pressure(s) in the next 12 months. The pressures represent both threats and opportunities, and, in declining order of importance, are perceived to be:

- seasonal conditions (e.g. W NSW, SW Qld)
- government regulations and imposts (examples given include NLIS, QA, EMS, health and safety compliance, etc.)
- rising costs
- lower prices
- other (e.g. not able to find suitable stock, lack of water in the Lower Darling, etc.).

Taking a wider view, and with respect to opportunities, it is clear that adjustment is transforming the rangelands in much the same way as the rest of rural Australia (Barr 2004). Over the period 1996-2001, and based on farmer/producer entry and exit levels, Barr (2004) has identified four patterns of adjustment:

a) tightly held (i.e. below average entry and exit rates) e.g. Cape York, S Qld, SW NSW
b) consolidation (i.e. low entry and high exit rates) e.g. channel country
c) churning (i.e. high entry and exit rates) e.g. northern and western Australia
d) fragmenting (i.e. high entry and low exit rates) e.g. arid areas of SA and NSW, SW Qld.

Although caution is required, recent adjustment patterns, together with expected business conditions and industry optimism, can be used to highlight geographic areas of employment opportunity.

EMPLOYMENT OPPORTUNITIES

Vacancies can arise through new jobs (i.e. employment growth), job changing (i.e. changing jobs but remaining within the same occupation), and job openings (i.e. through workers leaving an occupation). National data on vacancies are available for the broad sector of livestock farming (which is largely in, but not restricted to, the rangelands) (DEST 2004). In this sector, short-term employment growth has been in decline over the two years to May 2003, and the likely future medium-term employment growth is expected to decline (DEST 2004). Job changing is expected to provide 62% of vacancies and job openings 38% of vacancies (DEST 2004). Of course, this will vary with region, and may be linked to the patterns of rural adjustment identified above.

People are not hiring and will not hire staff in areas where business conditions have been 'weak' or 'neutral' and where conditions are not expected to be much better over the next 12 months. The vast majority of these respondents were wool or sheep producers, and they indicated that they had shed or will be shedding staff over the next 12 months. Seasonal conditions (e.g. drought) were an impediment for some pastoralists, but health and safety obligations and employment conditions (e.g. loadings) were the most common barriers to hiring cited by industry respondents. In the case of agencies, the common barriers to hiring were changing government priorities, reduced budgets and/or limited industry funds.

From the feedback, and assuming that weather conditions do not deteriorate dramatically in the sort term, there will be a significant number of positions available in the rangelands in 2004-2005:

Grazing (family and corporate) enterprises

In areas where business conditions have been strong and are anticipated to be stronger in the next 12 months, a significant number of enterprises will be hiring staff. The majority of the large pastoral corporations surveyed anticipate hiring to maintain staff numbers, with a few hiring to support recent property acquisitions. Given recent reports in the media of difficulties in filling rural positions (e.g. Watt 2004), it seems that demand exceeds supply in this area. Survey respondents anticipate the following vacancies over the next 12 months:

- Stockmen/farmhands
- Head stockmen
- Managers
- Property development officers
- Environmental managers.

Agencies

Some of the agency positions will be new (i.e. funded with industry or government funds), but the majority will be to replace people who have moved on or retired. The intent of any planned hiring generally appears to be to maintain staff numbers, although some states (e.g. Queensland and South Australia) anticipate some small growth in staff numbers. As at April 2004, only NSW agencies anticipate some shedding of staff, and this is largely due to changes in agencies such as NSW Department of Infrastructure, Planning and Natural Resources and NSW Agriculture. For example, the latter will be combined with a number of other agencies (covering forests, fisheries and mineral resources) from July 2004 to form the Department of Primary Industries, and some reduction in overall staff numbers is anticipated. Overall, the changes in NSW could result in significant redundancies, and if so, it is likely that supply will exceed demand and there will be few additional opportunities for agency employment. However, survey respondents elsewhere in Australia anticipate the following vacancies in the next 12 months:

- Pastoral/rangeland officers and inspectors
- Rangeland extension officers
- Regional planning officers
- Sustainability/sustainable management officers
- Natural resource management/nature conservation advisors
- Natural resource management/community development facilitators
- Production (e.g. wool, beef cattle) specialists
- Rangers
- Land management/Indigenous land management officers
- Researchers
- District and regional managers
- Pest/weed management officers.

Carmel Wagstaff's paper (this volume) lists further rural-based employment and career opportunities, while other significant opportunities will occur in the rangelands in the mining and tourism industries. Indeed, in a number of rangeland areas, the wages, facilities and conditions offered by the latter industries are attracting people away from traditional rural employment.

Turnover of staff is a characteristic of the rangelands. The average annual rate of net exit over the period 1996-2001 is about 5% in the rangelands (Barr 2004). Average annual entry rates are around 4.5%, with projections suggesting a slow, steady net decline in population in the rangelands over the next 25 years (Barr 2004). In areas dominated by the grazing industry, average entry age is high and has risen significantly over the last 15 years (from 35 to 41 years) (Barr 2004). This in part reflects the widespread trend of almost three times as many young people (15-24 years) leaving country areas than arrived in these areas in 2001 (Barr 2004). It follows that ageing will become an increasingly important issue for the grazing industries.

It is clear that the major challenges will be to a) attract and retain good people, and b) to upskill experienced people who are already in the rangelands and who have commitment to the rangelands.

QUALITIES SOUGHT BY EMPLOYERS

In response to a survey question about the qualities and skills that would be sought in new employees to be located in the rangelands, the following responses were offered:

Station work

- positive attitude (i.e. want to work and want to work in the rangelands)
- experience (i.e. remote areas, livestock, basic mechanics, etc.)
- independence, but also willingness to work in a team
- reliable and responsible (i.e. safety conscious)
- practical
- motivation and initiative
- common sense
- problem solving
- honesty
- willingness to learn
- willingness to comply with requirements (e.g. wear safety gear)
- qualifications (e.g. Certificate or above, with ChemCert, etc. desirable)
- basic stock and mechanical skills.

Communication, people management and administration skills were also identified, but these were usually associated with higher level jobs (e.g. head stockman, station manager).

Experience of the bush (even for only short periods such as vacation work) and the grazing industry were valued, but not seen as essential. Several potential employers (corporate and private) noted that a broader experience/skill set would be valuable, and that if many of the qualities listed above (and especially a positive attitude) were held, then knowledge and technical skills were not as important, as these can be developed through informal and formal training.

A number of the corporations also noted that they have to recruit more and more from urban areas. In these cases, there has been a need for induction programs to develop basic skills and to 'weed out' those who appear to be deficient in other desirable qualities.

Agency work

- qualifications (i.e. tertiary – broadly based and specialists, with specialists understanding where their area of knowledge fits into businesses in the region)
- experience (broadly based, and especially rangeland experience, also land management, grazing industry experience, etc.)
- positive attitude/empathy towards the rangelands
- communication and facilitation skills
- integration and synthesis skills (i.e. integration of information from different sources)
- people management skills (i.e. comfortable with/relate to a wide range of stakeholders from producers to scientists)
- operational / practical skills (e.g. first aid, 4WD, use of fire, etc.)
- sound knowledge (especially technical skills relevant to production and environment / sustainability, and including rangeland ecology, landscape function, holistic management, economic implications of technology / recommendations, etc.)

- organisational and project management skills
- resilient
- independent, self directed/starter, self confident.

The need for qualifications <u>and</u> experience was emphasised by most agency respondents, with some acknowledging that even vacation/ practical/ work experience in the rangelands was seen to be a significant advantage to applicants for agency positions. However, some might argue that this is not enough.

FURTHER TRAINING – AN EXPECTATION OF EMPLOYERS

From the survey, training and further education are widely seen by the grazing industry as important to improve competitiveness, foster innovation, ensure compliance with regulation, quality assurance, etc., and to retain staff. Agencies are undertaking training to improve their effectiveness and efficiency, ensure compliance with legislation, duty of care, etc., and to retain staff. Both groups of employers expect staff to be willing to learn (through informal and formal training).

Grazing Enterprises

All of the pastoral corporations and 90% of family enterprises surveyed indicated that they would be undertaking staff training over the next 12 months. Those producers who anticipate hiring over the next 12 months all indicated that finding suitably skilled or qualified people, and people who want to work in remote areas, are the major impediments to taking on new people. These issues have recently attracted media attention in the cities (e.g. Watt 2004).

The main areas of training anticipated over the next 12 months in family and corporate pastoral enterprises include (in no particular order):

- Finance / business skills
- Computer skills
- Livestock handling and herd improvement (i.e. breeding, nutrition, etc.)
- ChemCert, OH&S, etc.
- Pasture identification and management, grazing management
- Leadership and personal effectiveness skills (e.g. time management, communication, etc.)
- Land and environmental management, property planning and development
- Marketing
- Estate and succession planning.

Agencies

Among the agencies, almost all (i.e. 95%) respondents anticipate continuation of 'in-house' / 'on-the-job' training and some support for professional development, although budget constraints may limit the scale of staff training and further education in some states. A number of respondents also indicated that there would be at least continuing (and perhaps growing) support for further study, such as part-time postgraduate coursework and research degrees.

The main areas of agency staff training and further education anticipated over the next 12 months include:

- Information technology and computer skills

- Cultural and stakeholder awareness (especially indigenous and cross-cultural training), and engagement of stakeholders
- Facilitation skills
- Communication (i.e. presentation, report / grant writing, etc.) and media skills
- People management and leadership skills
- Regional planning, water management and fire management skills
- Livestock production (for NRM/environmentally trained people)
- Natural resources management (for production trained people)
- Project development, management and evaluation, contract management
- Operational / practical skills (e.g. defensive and 4WD driving, OH&S, etc.).

ALIGNMENT OF PROPOSED TRAINING WITH PERCEIVED SKILL GAPS

Taylor (2003) identified a number of knowledge and skill deficiencies in most producers and agency staff that could limit their capacity, in the medium term, to respond to expected changes in the nature of rangeland enterprises and their operating environment. Training proposed in the short-term by enterprises and agencies will address some of the skill gaps, but insufficient attention is being given in the following areas to skill development to meet medium-term needs:

Grazing enterprises

- environmental management systems and certification
- multiple-use management
- sustainable production systems and landscapes
- awareness of global and national trends influencing the rangelands
- legislation and regulations
- stakeholder values, perceptions and aspirations for the rangelands.

Agencies

- sustainable production systems
- stakeholder values, perceptions and aspirations for the rangelands
- environmental management systems and certification
- multiple-use management
- awareness of global and national trends influencing the rangelands
- business management and planning.

The limited activity in the above areas may be due to a different focus of training (i.e. retrospective vs prospective, or short vs medium term skill needs), a lack of awareness of the importance of the above skills, and/or a lack of suitable education and training products. New industry-responsive short courses and postgraduate coursework programs that Rangelands Australia / The University of Queensland have introduced this year will go some way towards meeting the latter need. These courses are specifically designed to meet prospective skill and knowledge needs, to extend the learning pathway in rangeland management, and broaden the options for a career in the rangelands.

CONCLUSIONS

Positioning yourself for a future in the rangelands requires:

- an understanding of:
  - the likely changes in enterprises and the expectations of rangeland users and managers, and
  - where the job opportunities lie (in a geographic sense and in terms of the skills in demand)
- a willingness to learn and to continue learning (informally and formally)

- a determination to strengthen the critical personal qualities and knowledge that are fundamental to success in the rangelands (see Taylor 2003).

The information presented on the qualities sought and the training proposed by employers provides sound guidance about the expectations of those wishing to embark on a career in the rangelands, and those seeking advancement.

It is an exciting but challenging time to be working and living in the rangelands. There are now a number of employment agencies specifically dealing with job opportunities in the rangelands, and a growing number of more relevant educational products and services available in the rangelands.

There are plenty of opportunities for a bright future in the rangelands, and these should be well within your grasp if you have a positive attitude to change and a willingness to learn!

ACKNOWLEDGEMENTS

I would like to thank the senior members of family and corporate grazing enterprises, and senior agency staff, who took the time to complete either a postal or telephone survey.

Trish Andrews, Robyn Cowley, Denise Hart, Janet Kieseker, Terry Omond, Rob Speirs and Carmel Wagstaff provided valuable comments on a draft of the manuscript.

Through Rangelands Australia, Meat and Livestock Australia, The University of Queensland and the Department of Agriculture, Fisheries and Forestry have variously supported the development of new postgraduate programs and short courses in rangeland management.

REFERENCES

Barr, N (2004). The micro-dynamics of change in Australian agriculture: 1976-2001. Australian Bureau of Statistics, Canberra.

DEST (2004). JobSearch - Livestock farmers. Available at:
http://jobsearch.gov.au/joboutlook/default.aspx?PageID=AscoDesc&ASCOCode=1312; (accessed on 24 April 2004).

Rabobank (2004). National survey results. Available at:
www.rabobank.com.au/inside_rabobank/news/media_releases/media_release_290304.asp; (accessed on 27 April 2004).

Taylor, J.A (2002). Key personal attributes and areas of knowledge for future success in the rangelands. *In*: Proceedings 12th Biennial Conference of the Australian Rangeland Society, Kalgoorlie, W.A.; pp 74-78.

Taylor, J.A (2003). Building capacity in Australia's rangelands. *In*: Proceedings VIIth International Rangelands Congress; 26th July-1st August 2003, Durban, South Africa; pp1801-1808. Available at: www.rangelands-australia.com.au.

Wagstaff, C (2004). Ensuring employment opportunities in the rangelands of Australia. *In*: Proceedings 13th Biennial Conference of the Australian Rangeland Society, Alice Springs, NT; (this volume).

Watt, A. (2004). Farmhand shortage worst for 20 years. Available at
http://www.couriermail.news.com.au/common/story_page0,5936,9643947%255E3102,00.html (accessed on 27 May 2004).

MULTIPLE PATHWAYS TO SUCCESS IN LAND MANAGEMENT

Jenny White

AACo, Canobie Station, via Julia Creek, Qld 4823

ABSTRACT

This paper elaborates on my position as rangeland manager for AACo, my experiences and challenges in this role, and highlights issues critical to achievement and success in rangeland management. In rangeland management the key to success is keeping an open-mind, and understanding issues, the people and the history of the issues.

INTRODUCTION TO AACO

Managing the land resource is crucial for one of Australia's s largest pastoral companies, the Australian Agricultural Company (AACo). The company owns 23 stations (totalling 7 million hectares) in the Northern Territory and Queensland, of which 99% are classified as rangelands.

AACo recognise rangeland management as an integral component of their production system, hence my position as a rangeland manager for AACo. I joined the AACo as the first rangeland employee in 1999. I was relatively 'green' to the field of natural resource management, but had plenty of practical knowledge and know-how of station operations; cattle management and most importantly, I understood the people, and their attitudes. If I did not have these qualities I believe that I would not be here today.

I am based at Canobie Station 200 km north of Julia Creek in north Queensland. My role with AACo is to work closely with station managers in developing natural resource management plans, assist managers in monitoring and dealing with local control and management issues. Numerous changes and developments have occurred in rangeland management within AACo in the past few years, which has resulted in the employment of an additional staff member specifically to deal with rangeland management issues.

WORKING FOR A LARGE PASTORAL COMPANY

The opportunity to work for a large, competitive, ever-expanding pastoral company is an experience in itself. My position is extremely dynamic, challenging and occasionally frustrating, but I have the opportunity to work on many issues across a wide assortment of land types and climate variability. The main issues recognised as being the drivers in maintaining AACo's landscape health and profitability are listed below.

- Noxious weed control and management,
- Fire control and management,
- Remnant vegetation and riparian management,
- Pest and feral animal control and management,
- Vegetation thickening and encroachment control and management,
- Feedlot environmental management,
- Pasture management,
- Ground water management,
- Stream water health,

- Infrastructure management,
- Soil health including erosion control and management,
- Conservation management,
- Pollution, chemical and waste management.

Over and above the environmental issues, a sound understanding of station operations, herd dynamics, nutrition, herd behaviour patterns, marketing and livestock logistics are necessary background information to developing land management plans.

From my experience, there is no expectation to know and understand all of the above, but it is more important to know how it fits together. Similarly it is important to form strong working relationships and alliances with land managers, neighbours and agencies to enable you to pull it all together. Using a bit of common sense, combined with listening and willingness to learn, will get you a long way and, most importantly will earn respect.

Rangeland management in AACo includes provision for developing its natural resources to provide adequate financial returns to its shareholders whilst embracing environmental strategies to achieve ecologically sustainable development.

I have a basic understanding of how our activities affect these drivers, but for each situation, the process of controlling the issue or hazard is frequently different because the cause(s) often differ.

MAKING A DIFFERENCE

Land managers are busy people and often not likely to adopt new technologies or management techniques unless prompted or at least supported. Managing change is a very delicate process and can be threatening if all and sundry do not fully understand the processes or outcomes. There have been numerous changes and achievements within AACo's rangeland management in the past four years including:

- Development of pasture monitoring system/s,
- Installation of almost 200 pasture monitoring sites,
- Installation of exclosure sites,
- Installation of 15 weed monitoring sites,
- Fencing off of three mound springs accompanied by conservation agreements,
- Fencing off of 170 km of riparian land,
- Replacing 2 bore drains with articulated watering systems,
- GIS mapping of 19 stations,
- Comprehensive weed management plans on all stations,
- In excess of $2 million invested in weed control and management activities,
- Environmental Management Plans being developed and piloted,
- Forming 10 sub-catchment community groups for weed control (involving 11 individual AACo stations and 20 neighbours),
- Instigated research and development projects.

AACo recognises rangeland management as an integral component of their production system and have really given me ample opportunities to identify and justify the need for many land management projects. Without the financial and moral support of AACo, and the forward thinking of its senior management, I would not have been able to achieve what the station managers and I have done to date.

KEY TO SUCCESS

The key to successful land management is to be open-minded – understand the issues, understand the people and most importantly, learn and understand the history of these issues. In land management planning, the aim is to identify the potential risks to our grazing lands and manage them by maintaining land in good condition and/or changing the management regime(s) to suit the management goals.

During the process of change, no matter how small or large a change, from my experience it is important that both you and your colleagues fully understand and comprehend all of the opportunities and threats of what you are doing, otherwise outcomes may not be as expected.

Huge financial outlays are often required to achieve the change and the desired outcome, so in such cases you must be meticulous in researching and planning what you are trying to achieve.

Leadership is essential when developing or facilitating land management plans. A leader must have the respect of colleagues to enable them to drive processes in the desired direction. From my experience this requires:

- Good people skills,
- Sound knowledge of what they are doing,
- Ability to listen and communicate with stakeholders,
- A positive attitude,
- Diplomacy,
- A willingness to learn,
- To be independent,
- An open-mind at all times.

If you have these qualities, or at least some of them, you will earn respect from your colleagues, be more effective, and will have a bright future in rangeland management. A lot of these qualities you do not normally learn at university, and they are important to strengthen as part of your personal development.

LAND MANAGEMENT PLANNING

The pathway to success in land management is not straightforward. Land management planning for individual stations is a process that requires:

1. Land manager involvement.
2. Stakeholder involvement and partnerships.
3. Understanding risks involved in implementation.
4. Transfer of knowledge.
5. Understanding people, the landscape, science, history and legislation.

Land manager involvement

Most land managers have a lifetime of experience in the rangelands and they are acutely aware that for them to produce high-quality cattle, they must first seek the harmonious balance between production and maintaining key soil, water and biodiversity values. Land managers may not talk this lingo but they are very aware of changes that go on around them and are at the forefront of monitoring and understanding changes in their landscapes, and are in the position to do so on a daily basis.

In land management planning, it is a team effort. And the most important contributor to land planning is the land manager. When developing plans, capacity building of the land manager is imperative. The land manager must feel as though it is his/her plan, and feel an important part of the process because after all, he/she will be the driver and implementer of the plan.

My position, I believe, is to act as the 'middle man' to talk through issues with station land-managers, liaise with technical and extension personnel, and work through a plan with the station manager on dealing with the issues. For the plan to be successful, the land manager must feel as though he is the one making the difference – not you as the facilitator.

Stakeholder involvement and partnerships

Most land management issues are best addressed on a regional/catchment basis. An excellent example of this was in 2001, when, in conjunction with DPI, I undertook an economic study to justify significant increases in weed control expenditure on our Gulf stations. Prior to this study, I had facilitated the development of weed control and management plans with each individual station manager. The outcome of the joint study demonstrated that a regional approach to weed control was necessary and that the proposed AACo control programs would play a major role in an effective regional approach to the problem. Fortunately, at this time, new financial outlays became available through the Weeds of National Significance (WONS) program enabling station managers to contact their neighbours to form sub-catchment weed control groups. Ten AACo stations formed their own individual sub-catchment groups and were successful in obtaining approximately $433,000 over three years. The majority of these funds went to other stakeholders – AACo stations utilising less than 17% of these funds, however the AACo contribution was significant in the achievements of many of these projects.

My role was to inform and empower station managers individually. Station managers then contacted their neighbours and let them know of the opportunity and organised a meeting/s. I only assisted the groups in filling out their funding submissions. Most of these groups were highly self motivated and have worked very well together in the control and management of woody weeds. This example again emphasises the importance of strong people skills in making a difference in the rangelands.

Risks in implementation

The greatest risk in implementation is lack of understanding. This can be overcome to some degree by involving professionals for guidance and recommendations.

There are huge gaps in understanding of rangeland landscape functioning, and when dealing with rangeland issues you often have to take risks using the best available information (even if it is "old"), make assumptions, monitor the outcomes, and adapt your management. In such situations it is essential to work and think 'SIMPLE and PRACTICAL' to ensure greater ownership by the land manager for implementation, monitoring and review purposes.

I have learnt that being too innovative can be a risk in itself. Developing new ideas and ways of doing things can get you into trouble in some circumstances. When I come up with a new idea, I cautiously throw the idea around for comment and 'shaping' (through general discussion) before pushing it further. This approach will build the capacity of those who comment – it generates interest, thought and often leads to greater ownership of the idea, which often enhances implementation of the new idea.

Transfer of Knowledge

AACo encourages relationships and dialogue with research and development organizations, environmental groups and regional bodies to facilitate two-way feedback on issues. Again, this gives us access to a wider pool of knowledge and experience, and this enables us to refine issues by incorporating community concerns and enables these organizations to refine aspects of their projects and plans.

Understanding

The pathway to successful land management is derived from the understanding of:

- People,
- Landscape,
- Science,
- History, and
- Legislation.

Understanding the people

As mentioned earlier, land management planning is a team effort. And a good team requires an understanding of one another, where they come from, why they do the things they do and what they are interested in.

Agency staff, consultants and land managers, all can be set in their ways – it's human nature. But understanding their background and experiences will enable you to understand where they are coming from and you will ultimately be in a better position to facilitate an approach to land management planning.

In land management planning, the importance of understanding the land manager is vital to the success of a land management plan. They are very busy people, and very practical; mostly outdoors type people so the type of plan you develop must be simple, practical and coherent to their way of thinking and operating.

Understanding the landscape

Land management commences with mapping (GIS) of station infrastructure and land types; utilising satellite imagery, global positioning system (GPS) technologies and obtaining information from government agencies. In addition, issues (e.g.: location of woody weeds, erosion etc), monitoring sites and conservation areas etc are included on infrastructure maps. GIS is the most valuable tool in land management; as it visually links and puts the landscape and current management practices into perspective for developing future best practice.

Probably the most important facet of mapping is the ability to assess safe carrying capacities for different land types. To compliment this technology, AACo stations have established almost 200 pasture monitoring sites in order to determine trends in land type condition and assist in arriving at feed availability to determine safe stocking rates.

However, in much of the rangelands in Australia, we know very little of our landscapes and how they function. Hence we often need to make assumptions and carefully monitor and document outcomes to improve our understanding of the landscapes.

Understanding the science

There is very little scientific knowledge of much of Australia's rangelands. Land planning must continue irrespective of what information is available. This is where land manager, agency and community partnerships, together with historical records, are invaluable in land management planning.

Understanding the history

The pathway to successful land management is best determined by understanding historical events prior to the present. The reason for things being the way they are in the present day is determined by the past – whether it is climatic/seasonal history, cultural or indigenous history, past land use or previous developments. Understanding these events will inevitably put you in a sound position for successful future land management planning.

Understanding legislation

The understanding of specific environmental legislation, guidelines and codes of practice is important in determining our responsibilities in land management.

OPPORTUNITIES IN RANGELAND MANAGEMENT

Living and working in remote rangelands of Australia is a brilliant and very satisfying lifestyle. The landscapes are incredibly unique and spectacular with plants and animals that reflect much of the character of these special regions. And the people are remarkable.

Unfortunately in many areas of northern Australia, there are too few positions available in agencies or consultancy organisations in rangeland management. And when these positions do become available, they are often difficult to fill because people do not want to live and work in remote areas, or the positions are limited in timeframe due to short-term funding.

If you have empathy for rangelands, its people and its history and a basic understanding of operations and industry, you will be in a great position for a successful career in rangeland management. In addition, good communication skills and experience of industry and the rangelands will be extremely valuable. A good sound ecological understanding of rangeland landscapes would also be an advantage, but can be learnt if you are prepared to be observant, to listen to others, and to experience the annual and longer term cycles of good times and bad times.

University, or any study for that matter, is important backgrounding and will build your capacity for learning and develop essential skills/ knowledge for the management of rangelands. But study alone will not make you a successful rangeland manager. The rangelands are a complex place, and to be effective in managing them you will need to understand the industry, the people and the operations of which you are a part. It is relatively easy to overcome these complications if you take on the challenges by making strong working relationships and alliances with people with an open mind.

CONCLUSION

The pathway of land management embarked on today will ultimately determine land condition and performance into the future. So it is imperative that we get it 'right' now by ensuring we accumulate all of the facts, assumptions, experiences, the history and the science together to make certain we can get it as 'right' as possible.

The pathway undertaken in land management planning should be determined by the people – their experience, attitude and objectives; the science; and understanding the history of issues. In land management planning, we are all aware that our rangelands are a complex ecosystem but need to ensure that our plans are SIMPLE and PRACTICAL and tailored to the needs of each operation.

In addition, to be successful in managing rangelands you and/or your colleagues will need to understand or have the ability to acquire an understanding of the operation of which you are working, their objectives, and become familiar with drivers which are important in maintaining landscape health and profitability. Furthermore you must be able to comprehend opportunities and threats to the operations of which you are a part. The challenge of understanding can be overcome through doing a bit of research, but it is most important to be open-minded and willing to learn from others and their experiences, especially in circumstances where there is a lack of science and knowledge available.

As rangeland manager for AACo the most important factor that enables me to take risks and ultimately make a difference is having the support of senior management and the cooperation of land managers themselves. Having the support of my colleagues and living amongst our natural resources, I have the advantage of seeing, understanding and networking readily with issues and the people. This is a very motivating and rewarding experience that is good backgrounding for future professions, whether it is as a land manager or in an agency or consultancy position.

WHY ARE CHAINS IMPORTANT?

Murray McGregor

Desert Knowledge Cooperative Research Centre,
Muresk Institute, Curtin University of Technology, Northam WA 6401

ABSTRACT

Businesses operating in our rangelands are subject to a wide range of pressures, both external (such as globalisation, information technology, sustainability, power of consumers/retailers, etc) and internal (such as the small size of businesses, isolation from major markets, a rising indigenous population requiring sustainable forms of employment). How businesses react to these challenges determines whether these pressures will lead to opportunities or threats to the business.

Modern chain theory has highlighted the need for business to shift its focus from a supply to demand focus. In addition, there is need to develop strong relationships along chains where the benefits as well as the risks associated with product supply are shared. But all these factors play out differently in rangelands, because of their special environmental, social and cultural characteristics. This paper will highlight how regional and remote businesses can use this new complex environment to develop and/or maintain sustainable and viable businesses. The new emphasis will be on finding products that the market wants and developing strong supply chain relationships, marketing and supply partnerships.

SO WHY ARE CHAINS IMPORTANT?

The term chain can refer to network, supply, demand and value chains which all have a particular meaning but have as their basis the pathway through which a series of inputs are transformed into products that end-consumers desire. This is generally seen as a linear process in which the inputs from one stage in the chain are transformed into a product that forms an input in the next stage of the chain or in fact the final product (McGregor 2002). Chains operate in an environment that is influenced not only by the attributes of the businesses involved in the chain but also by the range of external influences impacting on the chain. These may range from influences such as weather and trade policy over which individual businesses have little control through to internal policies relating to ethics, animal welfare, social justice and the environment.

There is no doubt that a major external influence on our food supply chains over the past ten years has been globalisation, a concept that the food industry has embraced, or been embraced by depending on how you look at it. The ever-changing socio-economic and demographic trends and the plethora of food quality scares internationally mean that the food industry has to be able to react quickly to global changes which often bring with them opportunities. As an example the recent bird flu scare in Asia meant that Western Australian egg producers suddenly had the opportunity to develop an export market which wasn't previously available to them. The BSE and foot and mouth incidents experienced in the UK and elsewhere have opened new markets for Australian beef but more subtly have presented Australian beef producers with a new market – organic beef. In general globalisation has meant that our food supply chains have lengthened and broadened to include new market opportunities that had not been thought of previously. The significant changes that we have also experienced in information and transport technology mean that food markets are now truly global and this applies to fresh as well as processed products. For instance fresh pork carcasses and ice cream are now flown daily from Western Australia to Singapore.

Globalisation has opened up many opportunities for Australian food and related businesses but there is also a need to recognise the discipline and changed business structure that this brings. In the early 1990s the focus in supply chains was one of producing goods and pushing them along the chain. Partners in supply chains were selected on their levels of technical excellence, their ability to meet service targets and of course the price of the goods supplied. Relationships were very much transactional. The major shift in the later part of the 20th century and the early 21st century has been to maintain these requirements but add to these stronger relationships and whole-of-chain and customer-focused components such as having a strategic orientation, through chain innovation, offering some exclusivity to supply and the sharing of profitability along the chain.

Another major outcome has been a shift by major international retailers to dealing with fewer, larger suppliers. This means there is a role, and need, for consolidators in our supply chains, and this role increasingly is being met by supplier owned and operated businesses. Consolidation poses problems in the rangelands due to the dispersed nature of our production units but the significant improvements in information and communications technology mean that many barriers associated with the tyranny of distance have been reduced considerably. If Wal-Mart can source fresh food on a daily basis from all around the world then we should be able to aggregate supply within the rangelands of Australia.

However the biggest change we are seeing in chain management is the concept of chain competing against chain. This obviously causes problems for many Australian suppliers who have had a strong tradition of competition between businesses but to be competitive in the international markets in particular, companies need to cooperate more. The new catch cry is *"to compete locally but cooperate globally"*. The underlying principal in chain versus chain competition is that relationships within a chain then become very important. The traditional transactional-based focus that relied on contracts has been widened to include new concepts involving networks and relationships. In their purest sense the supply chains openly share information up and down the chain in an environment of complete trust (Batt 2003). In many cases the model adopted involves the complete openness of financial books along the chain and the sharing of profits.

Trust has long been an important component in any business relationship but is the critical element in this new environment. With it there is an environment in which there is an open exchange of ideas and emotions, clear goal setting and problem identification and a wider search for new markets and enhancing existing market share (Achrol 1997). These factors combine to deliver greater satisfaction for businesses in the chain and higher levels of motivation to implement joint decisions made by chain players. When high levels of trust exist, businesses can focus on the core business of the chain in an environment of less perceived risk and not be continually looking for alternative business relationships (Moorman *et al.* 1993), thereby reducing the transaction costs associated with exchanges within the chain (Ganesan 1994, Doney and Cannon 1997). In many instances partners who are committed to the relationship and trust one another will be prepared to make short-term sacrifices to realise longer-term benefits and also embark on relationship-specific investments that are specific to that transaction.

Obviously the development of such close relationship along a chain can result in high levels of dependency between partners in the chain. This can be both a positive and negative factor. As noted above if the process is working on an equal footing and no single partner exerts power over the chain, then dependence and relation-specific investment will help to reduce transaction costs. However, in a situation where one partner can exert power or a chain partner is more susceptible to the power and influence of another, then a situation arises where the more powerful partner may be in a position to demand more favourable terms of trade.

However, in the end the key to any successful chain or business is that it has identified a market(s) for its product. This may seem a basic requirement but it is often a step that many start-up businesses in regional areas neglect because they have been long conditioned by the belief that we can produce product and the market will be take the product. The days of supply driven markets are long gone. Markets are now clearly consumer and value driven.

RECOGNISING A MARKET OR HAVING A MARKET FOCUS

Markets vary in their levels of consumer sophistication and food supply chain efficiency (see Table 1). Levels of consumer sophistication range from those markets where consumers are actively seeking information on the provenance of the product and, in many cases, markets in which food at the top end of the market has largely become a fashion item in much the same way as clothes. At the other end, consumers are highly focused on price with factors such as nutritional quality and food safety playing a part in the purchase decision. Crossing over with this is the level of efficiency in the food supply chain. These range from the highly sophisticated supply chains of Europe and the US through to the fragmented chains found in the developing world.

Table 1. Australian agricultural exports by destination (adapted from Lojo 2003; data source, www.dfat.gov.au/trade)

Consumer Sophistication	Food Supply Chain Efficiency	*Country*	Share of Exports ($ m.)	(%)
High – *Active Decision Making*	*High*	USA	2,890	11.9
Brands, but actively seeking documented information on social and environmental concerns	✓ Supply chain integration	UK	971	4.0
	✓ Retailers directly influence production	New Zealand	826	3.4
	✓ Protocol control and contract growing	Canada	550	2.3
		Saudi Arabia	547	2.3
		UAE	325	1.3
		Germany	239	1.0
	Medium	Japan	4,806	19.8
Medium – *Less active decision making*	✓ Supply chain bottlenecks	Korea	1,012	4.2
Brands, but largely perceived quality, and health and nutritional values	✓ Large distributors control	Malaysia	967	4.0
	✓ Protectionist regulations	Hong Kong	886	3.6
	✓ Protocol control and contract farming	Taiwan	741	3.0
		Singapore	583	2.4
		Egypt	545	2.2
		Thailand	337	1.4
Low – *Price-driven decision making*	*Low*	Indonesia	1,005	4.1
Brands but affordability, basic concerns on safety and nutritional values	✓ Fragmented supply chain ✓ Multi-layer of intermediaries	Philippines	696	2.9
	✓ Retailer remote from production base	China	689	2.8
Mixed		Other	5,585	23.4
		Total	**24,300**	**100.0**

NB. Sorted according to share of exports

This generalised classification of markets, although useful, fails to pick up the complex web of demographic and consumer trends/needs embedded in each grouping. For instance if we look more closely at the markets which are categorised as having high levels of consumer sophistication and efficient supply chains (countries such as Japan and the nations of Europe and North America) we see some quite worrying signs in terms of their demographics. Like Australia, the birth rates in these countries are insufficient to reproduce themselves; younger people are no longer able to support a growing population of older non-working people with the consequence that they cut back at the other end of the spectrum by having fewer or no children. Only the US is producing sufficient births (2.4 per woman) to barely maintain the current population. In southern Europe (Greece, Italy[1], Portugal and Spain) the birth rate hovers at around 1. In Germany and Japan[2] the rate is around 1.5. In this

[1] The official forecast of the EU is for a drop in Italy's population from around 60 million currently, to fewer than 40 million in 50 years time and to below 20 million in 100 years.

[2] Statisticians for the Japanese government predict a drop in their country's population from the present 125 million to 55 million within the 21st century.

group of nine countries, which currently account for just under 50% of Australia's share of exports, the population is either in decline or at best maintaining itself, which means there are going to be a declining number of mouths that need feeding in the future. Australian suppliers will therefore either have to shift their emphasis to markets which are currently less sophisticated with supply chains which are less well defined but where the population is growing if they want growth through volume or be more strategic in gaining market share in existing markets and get growth through focusing on higher yielding market segments. I believe many of the opportunities for the rangelands are in focusing on the higher yielding segments but, as always, there will be specific lower-value, volume-focused markets such as live export that will provide opportunities. A note of caution however, in the case of the live export trade is that there are significant clouds on the horizon that in the end may see the cessation of the trade.

What are the current consumer needs/trends in those markets that currently exhibit high or growing levels of consumer sophistication? The major factors driving the food and beverage markets in these countries are quality, taste, convenience, health and indulgence. I haven't got time in this short paper to explore this thoroughly but I will discuss trends that will link with the two industry speakers in this session. It is also important to note that while food retail volumes remain fairly static in these markets, the value of sales has increased at rates of around 3-4% as a result of strong consumer buying of premium and specialty foods. Some of the trends of interest are:

The first is that consumers are becoming more sophisticated in their food purchasing with a consequential rise in purchases of gourmet specialty foods to *"... spice up everyday meals, rather than just using basic ingredients"* (Mintel 2004). This is also closely linked with the fact that the younger generation have lower levels of culinary skill compared to the older-aged groups and are therefore demanding higher quality and different ready meals and through travel, have become more adventurous with their tastes. The dimensions of these markets are huge with Mintel noting that this has translated into increased sales of specialty foods of over 20% between 2001 and 2003 with a market now valued at US$23 billion. These same trends have been observed to have an impact in the food seasoning and cooking sauces markets. Although the US seasonings and spices market, which is worth US$2.2 billion, has been described as mature with little growth (Mintel 2004) there are growth opportunities in exotic flavours and ingredients that are authentic with traceability of the ingredients provenance. The Australian rangelands contain many as yet unexploited (in market terms) exotic flavours and products that could be developed. These market segments could first be test marketed and refined in collaboration with tourist hotels in desert areas. The Northern Territory has also proven recently that companion marketing of products in the US and other markets can be a successful way of increasing market share especially in the high valued restaurant end of the market. The real key here will be to ensure that the provenance of the product is in no way compromised and that significant importance is placed on implementing systems that ensure traceability all through the supply chain.

The second major trend is an increasing demand for food products that people can eat on the move. This is especially the case in Europe where commuting times are longer and commuters are spending the time travelling to eat, drink or groom. This is known as *'on-the-move consumption'*, a category that now makes up 43% of the European snacks category[3]. A related trend is that less time in now devoted to cooking and eating meals despite the *'slow food'* movement. It is interesting to note that the time taken for food preparation and cooking at home has decreased from 2.5 hours in 1934 to an estimate of around 8 minutes in 2010. A recent report noted that even in France, that bastion of gastronomic excellence, the average time spent eating at a table had decreased from 1 hour and 22 minutes in 1977 to only 38 minutes in 2002. This suggests that there are openings for our food suppliers to either developing products that focus on supply to the food service sector and/or develop strong relationships in chains that manufacture ready meals. This might be as a component such as the flavours or the base ingredient in say kangaroo or organic-beef jerky.

---

[3] It is interesting to note that transport activity that generates most on-the-move consumption is walking which accounts for 24.1% of all activity but contributes 39.9% of the sales. So much for walk for fitness!

The organic food market was seen until recently as a niche market which catered for a select few but that perception has changed as consumers become more health conscious, more concerned for the environment and aware of the dangers associated with the production, processing and consumption of food (Mintel 2003a, RocSearch Ltd 2004, Packaged Facts 2003). The global organic food market is now dominated by the US and European markets but countries like Japan and Canada are showing growth. There was a period of rapid growth in the organic market in the latter part of the 1990s up until the end of 2001 but a recent report (Mintel 2003a) suggests that fewer customers are now buying organic products than in 2001. While growth has slowed committed buyers are now buying a wider range of products. An area of optimism for the rangelands is that the continuing scares about BSE are fuelling rapid growth in the organic meat market in Japan, US and Canada. The potential for our rangelands to produce a wider range of organic products is huge and as noted above there are considerable opportunities for development of new markets through companion marketing of say beef with other bush food products or even non-food items such as Indigenous art.

Another focus has been on the increase in demand for food products that have a functional food component. The increasing literature which links diet to many chronic diseases is encouraging consumers to look for products that prevent and treat disease and/or improve body functions (Leatherhead Food RA 2004). Mintel (2003b) has noted that '*wellness*' is the new standard from a consumer perspective. This manifests itself in the high-intensity sweeteners that allow companies to offer low-calorie foods and drinks, or herbs which when included in products provide proven energy boosts. Some recent Australian examples are Omega-3 milk and nutrient-enhanced cereals. The search is now on for novel food ingredients that confer favourable health functions. The potential in our rangelands is huge. Indigenous people have long known the functional benefits of a large number of rangeland flora and fauna. The key to developments in this area will be that that traditional knowledge is valued and returns a dividend to its owners as it is used in the new food supply chains. This is not a trivial matter and one that requires high quality research and the development of imaginative business structures,

Finally, a recent report (Lintott 2003) has noted that "*... the contemporary food trends such as organic vitamin-fortification or functionality are not yet prevalent in the meat snacks category*", There has been no reported instance of a meat snack that claims to be organic and enriched – it appears that being organic on its own is no longer enough. Perhaps this is an opportunity for the Australian rangelands.

CONCLUSIONS

Alexander Graham Bell once stated *"sometimes we stare so long at a door that is closing, that we see too late the one that is open"*, Opportunity is defined as a set of circumstances providing a chance or possibility, a stroke of good fortune that presents itself and can either be grasped or lost. Circumstances, positive and negative, are constantly around us waiting to be capitalised and when seized, opportunities will surface.

Take the experience of Edward Lowe back in the 1940s. He was in the business of producing a clay-based material that would soak up oil and grease spills. One day a neighbour asked to use the compound for her cat. It didn't track all over the house and besides that, it looked good. Favourable circumstances presented themselves and Lowe realised he was on to something. He began selling the compound to pet shops and went on to supply 40% of a $400 million cat litter market.

The point of this example is that there are no limits to our opportunities. Most of us see only a minute portion of what is possible. We create opportunities by seeing the possibilities and having the perseverance and determination to act upon them. Opportunity and perseverance are the engines of successful people and businesses as illustrated by the two case studies in this session. Those living in and making a living from our rangelands need to consider its opportunities and identify those "*strategic elephants*" which might prevent it from seizing them.

There is no doubt that the world is changing and that market opportunities will wax and wain with the ever-increasing complexity of today's economic, social, political and environmental constraints. In order to compete in this complexity, modern agribusiness participants need to be persistent and to keep an open mind to the identification and capture of opportunities, not only in easier times but in times of seemingly insurmountable odds. Firms need to move away from linear solutions to problem solving and to adopt a holistic approach that encompasses the whole supply chain and the social and physical environment in which the chain operates.

An Asian saying advises, "*When fate throws a dagger at you, there are only two ways to catch it, either by the blade or by the handle*".

Which way are you going to catch it?

ACKNOWLEDGEMENTS

I would like to thank the Desert Knowledge-CRC Board and Management Team and many people engaged in Desert Knowledge Australia, who helped to develop these ideas, although the expression of them here is my responsibility alone. This is a publication of the Desert Knowledge CRC, supported by funding from the Australian Government's Cooperative Research Centre Program.

REFERENCES

Achrol, R.S. (1997). Changes in the theory of interoganisational relations in marketing: Toward a network paradigm. *Journal of the Academy of Marketing Science* 25: 56-71.

Batt, P.J. (2003). Building trust between growers and market agents. *Supply Chain Management: An International Journal* 8: 65-78.

Doney, P.M. and Cannon, J.P. (1997). An examination of the nature of trust in buyer-seller relationships. *Journal of Marketing* 61: 35-51.

Dunne, A.J. (1999). The Marketing of Agricultural Products: an Australian Perspective. *Agribusiness Perspective.* Paper 48. www.agrifood.info/review/perspectives/

Ganesan, S. (1994). Determinants of long-term orientation in buyer-seller relationships. *Journal of Marketing* 58(April): 1-19.

Leatherhead Food RA. (2004). Reported at http://just-food.com/features. Accessed 19/05/2004.

Lintott, Amanda (2003). Latest trends to hit the meat snacks market. http://just-food.com/features_print.asp?art=720. Accessed 19/05/2004.

Lojo, H.M. (2003). Challenges in Agribusiness Supply Chain. Paper presented at 1st Mindanao Policy Research Forum, Davao City, Mindanao, The Philippines, 11 June 2003.

McGregor, M.J. (2002). Overview of major factors impacting agribusiness value chains. Proceedings of the Muresk 75th Anniversary Conference, *From farm to fork - Linking producers to consumers through value chains*, Perth, 3-4 October.

Mintel (2003a). Organic Foods – UK. Reported at http://just-food.com/features. Accessed 19/05/2004.

Mintel (2003b). Ingredient Trends – US. Reported at http://just-food.com/features. Accessed 19/05/2004.

Mintel (2004). The Seasonings Market – US. Reported at http://just-food.com/features. Accessed 19/05/2004.

Moorman, C., Deshpande, R. and Zaltman, G. (1993). Factors affecting trust in market research relationships. *Journal of Marketing* 57: 81-101.

Packaged Facts (2003). US Market for Organic Foods and Beverages. Reported at http://just-food.com/features. Accessed 19/05/2004.

RocSearch Ltd (2004). Global Organic Food Market. Reported at http://just-food.com/features. Accessed 19/05/2004.

THE "WISE" SUPPLY CHAIN: KNOWLEDGE AS A COMPONENT OF ITS SUCCESS

Denise Hart

Rangelands Australia, The University of Queensland, Gatton, Qld. 4343

ABSTRACT

Enterprises enter supply chains to improve profitability through product development that is responsive to consumer demands. Increasing market share and maintaining a competitive product depends on the ability of each unit in the chain to apply knowledge innovatively. The key to innovation is the application of explicit and implicit knowledge of the people within the organisations throughout the chain. With improving technology and a supportive learning environment, enterprises in the rangelands can add value by utilising the collective wisdom of the people in the organisation.

INTRODUCTION

Knowledge is the competitive advantage in a supply chain – it not only transforms the production but also the ability to foresee and manage complexity and change. The challenge is to create a value chain where people have the necessary skills to add value by developing, acquiring, exploring, sharing and applying knowledge – not just to resolve issues but to be innovative. Knowledge acquisition and application within the supply chain underpin the intellectual capital of the chain and its ability to ensure a competitive product and increased profit margin. Each component in the supply chain adds value for the client, derived from its specialist knowledge, to the final product. The quality and application of the knowledge throughout the chain has a direct impact on the quality and competitiveness of the product. It is a 'wise' supply chain that values the thinking capacity of its people. (Value chains are after all, relationships built on co-operation).

The 'value' in a value chain resides within the flow of thinking processes throughout the chain. The power to drive innovation within the chain lays within the people rather than the technology. The degree of value placed upon the acquisition and application of knowledge underlies the chain's ability to foresee and manage complexity and change. A wise supply chain engenders a climate of knowledge growth and acquisition as part of its business strategy realising that the decision making capacity of the people within the chain creates the value for the client.

Rangelands enterprises participating in supply chains are challenged by isolation and the informal nature of the learning which takes place within the enterprises. Building a supportive learning environment increases the knowledge capacity of an enterprise as well as being connected and switched into the issues and trends impacting on profit margins.

WHAT IS KNOWLEDGE?

It is indeed a wise person who knows what he does not know but it is even a wiser person who knows how to access information and develop this into knowledge. Knowledge starts its life as data, unrelated facts, that that have little value on their own. As data are combined and placed in a context, it becomes information. Information becomes knowledge through critical and creative thought processes. These processes generate meaning for the user that is verifiable. When insight is added to the accumulating knowledge then a person has moved to being educated, i.e., they have an understanding of how they know. Wisdom grows from the process of education where philosophical insight and moral judgements can be made though the skills of thinking, evaluation and decision making, and self-actualisation is evident. The learning cycle is continuous, each layer building upon another (Figure 1).

Where does the wisdom reside in the supply chain? It resides in the people, the quality of the relationships that are formed across the chain and the application of shared knowledge. The chain is a sum of all the parts and co-operative exchanges of information and knowledge across it ensures strategies and knowledge are aligned to its goals (Furlong 2001). Stakeholders within the chain have increased commitment to the strategic goals when they are knowledgeable about their contribution and when the culture encourages their contribution to knowledge growth. "The broader access members get to the meaning-making (knowledge) activities of the organisation, the better are their chances of increasing systemic wisdom" (Pór 2000).

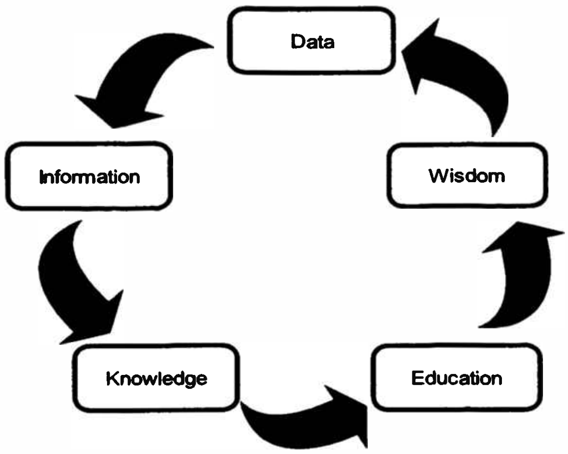


Figure 1. The learning cycle.

TYPES OF KNOWLEDGE

Knowledge has been classified as being tacit and explicit (Polanyi 1966). Tacit knowledge has two dimensions both personal and practical. It is embedded in people's ideas, values and emotions and is expressed more in people's actions. It is their 'know-how' and shapes the way they perceive the world. In the knowledge economy interest is growing in a person's tacit knowledge because "it is deeply rooted in action and individual commitment and to a specific context" (Nonaka 1991 quoted in Furlong 2001). Explicit knowledge is formal knowledge that is structured and recorded both in numbers and words. It is readily transmitted between people and "defines the intellectual assets of an organisation independently of its employees" (Stewart 1999 quoted in Furlong 2001).

Knowledge is not static as it moves between people. The real value of both explicit and tacit knowledge is in its application. Tacit knowledge flows from the people in the organisation to be made explicit in its policies, processes and practices. When technical writers are developing manuals, they aim to make the tacit knowledge acquired by the designer during the design phase explicit to the reader. When you consider all the communication issues of articulation and listening that occur during this process, it is not difficult to understand why some manuals are more successful than others. This is equally applicable to the translation of scientific research into the working context of rangelands enterprises.

HOW KNOWLEDGE ADDS VALUE

It is in the differentiation between information management and knowledge management that the value lies for business. Information management uses information technology to organise and deliver information about knowledge. Knowledge creation uses the tacit and explicit knowledge of the people across the network to develop new ideas, new ways of thinking leading to greater innovation and value creation. If the supply chain only focuses on information technology, i.e., the use of technology to manage information "without consideration for how knowledge is applied, growth may be limited as the exploitation of collective knowledge to innovate and grow the business is unlikely" (Davenport and Marchand 2000 quoted in Furlong 2001).

Value is added to the chain's business sustainability with the identification of relevant information and the application of knowledge to the strategic future planning. While productivity and product quality are components of the ultimate drivers of innovation – profitability, there are other dimensions where knowledge contributes towards a chain's sustainability. A growing number of organisations are realising that sustainability involves meeting the environmental and social aspects of the triple bottom line as well as financial goals. Knowledge management across this complexity ensures that time is invested wisely in meeting the growing client demand for products to be developed in a sustainable manner.

Without a process for developing new knowledge across the chain there is a danger of 'brainstapling' where history and habit ensures the business focus remains on what has always been. History and habit ossify thinking processes and leave the chain without flexible strategies for managing the future. Rigidity reduces the value of any knowledge input to the chain.

Supply chains that develop structures for knowledge management across the chain are actively seeking to aggregate the total knowledge potential of stakeholders to create value that is greater than the sum of the parts. The Economic Development Institute at Georgia Tech, Atlanta defines waste as "Any activity that consumes resources and creates no value. The eight types of waste are overproduction, waiting, defects, excess inventory, motion, transportation, over processing and untapped human potential". Without structured and supported knowledge management throughout the chain much stakeholder knowledge is never tapped and its potential value to the organisation is wasted. Human potential and any competitive advantages for the chain are subsequently never realised. A chain that is truly open to change will have found ways of removing hierarchical structures which inhibit the flow of communication vertically within organisations and horizontally across the chain. Guptara (1998) identified that communicating with "employees lower down in the hierarchy" would reveal whether an organisation was "genuinely open to new ideas". How many people employed in a rangelands enterprise understand the implications of customer requirements for their product?

Value is increased in the chain when reciprocal activities occur between employees and organisations in the chain. As stakeholders synthesise their knowledge to benefit the chain, the chain invests in the development of capability in its stakeholders both formally and informally. In the long term this investment in employees further develops the capability of the organisation and in the short term, employees solve problems and create new knowledge that builds momentum in the chain (Wenger 2003).

BUILDING KNOWLEDGE IN THE CHAIN

Information or intelligence comes into an organisation in many formats – paper, internet, television, radio. Each person who uses that information will process it differently depending on their preference for receiving information, learning and communication combined with their values and previous knowledge. The information becomes personal knowledge as critical thinking processes of analysis, evaluation, review and reflection are applied. As tacit internalised knowledge it may be expressed in action but the chain may not benefit from this new insight.

When a critical mass of stakeholders comes together to participate in purposeful knowledge sharing a greater diversity of ideas is generated. It is the synergy of the interaction that creates the value in processing of information. A chain encompassing a variety of personality types, communication and cognitive styles along with different operational knowledge, has a catalyst for innovation. Socialisation is the vehicle for externalising tacit knowledge, processing and then re-internalising new knowledge leading to action. A result of this process may also be that some knowledge is regarded as redundant at this point and put aside – another step in developing wisdom.

Redundant knowledge also includes "questioning the relevance of past experiences and its appropriateness in current and future situations" to produce "radical behaviour changes in the value chain, resulting in innovative actions and processes that increase competitiveness" (Furlong 2001). Reviewing current practice in light of new knowledge is essential if the chain is to ensure that 'best practice' remains just that, that core competencies remain relevant and that threats and opportunities are recognised and realistically analysed (Malhotra 1998, Furlong 2001). Rangeland enterprises need to have processes for identifying current knowledge and to ensure that people have the ability to evaluate situations in light of new and old knowledge.

CRITICAL SUCCESS FACTORS

Several factors contribute to the development of wisdom across the supply chain. Furlong (2001) identified business strategy, leadership, culture, context, organisational structure, technology and innovation as being enablers of knowledge management.

A value chain is a strategic network working co-operatively towards a common goal; therefore knowledge creation must be aligned to the business strategy and the output of quality products. Identifying the knowledge gaps in the chain that are aligned to the business strategy and processes to overcome these deficiencies ensures that the chain remains both competitive and sustainable. Processes to overcome gaps include education, training, mentoring or building a 'community of practice' around a particular interest area and aligned to the strategic goals. The alternative is to engage consultants and buy in the knowledge.

Leadership is essential in creating and supporting a positive learning environment. The leader is also a learner and a role model, developing a culture that is committed to sharing knowledge and creating new ideas to meet customer demand. At the core of knowledge sharing is the quality of the relationships throughout the chain. Emotionally intelligent leaders with both personal and social competence (self-awareness, self-management/social awareness and relationship management) will be able to anticipate needs and develop appropriate processes to meet those needs (Goldman *et al.* 2002, p. 54). This may be in the form of organising appropriate resources, e.g. technology to facilitate the knowledge flow across the chain, leading communities of practice, and being open to new ideas from all levels of the chain.

The quality and relevance of the initial information that flows into an organisation has a direct impact on the knowledge developed from its use. Information needs to be both timely and relevant to the context of the business. A toolbox of information and communication skills is used when accessing, using, evaluating and applying information. People working together with contextual information develop competence in knowing how and when to use these skills which impact on the way in which knowledge is developed. A rangelands' learning community develops when learning is acknowledged as an integral part of the enterprise's business function – knowledge is shared, people are open to new ideas and have the necessary skills to apply knowledge to the organisation.

Developing wisdom in the supply chain is a participative process for no one person in a climate of discontinuity can have all the solutions. Hierarchical structures tend to silo knowledge and discourage sharing. Opposite to this are bottom-up groups of interest or communities of practice established around a common interest and co-ordinated across the chain. These groups bring together implicit and explicit knowledge from a range of perspectives (Wenger 2003). They are a means of mentoring new members in a supportive learning culture with regard to the business strategy and how they can contribute. Lave and Wenger (1991, p. 31) identified that "learning is an integral part of social practice" and that this type of learning involves the whole person rather than being just a cognitive activity. The social nature of the 'community of practice' is an ideal forum for members to integrate the knowledge gained from formal learning into the chain, increasing the value of that learning both for the participant and the chain.

Networking core business activities throughout the chain builds the knowledge and skills in each of these areas and increases the opportunity for innovation throughout the chain. Positive attitudes and commitment underlie a person's motivation to participate in the flow of information within an organisation. Preventing the knowledge flow has implications for the whole chain in the quality of its products. Equally so, if a producer is unaware that their non-participation in a chain in the region affects the success of the chain, the chain will falter. Communities of practice could be centred on areas that involve people at all levels of the enterprise, e.g. technical aspects, environmental management, food safety and biosecurity, animal welfare, human resource management. Furlong (2001) further suggests that this gives a competitive advantage to the chain as increased knowledge, skills and experience in core business areas become an entry barrier to competitors. New entries would not have developed that degree of knowledge and skill but could obtain it by takeovers or head hunting.

Communities of practice as collectives of diverse stakeholders are subject to all the issues that impact on participative processes. Development of stakeholder's participation skills such as group cohesion, power sharing, communication and learning styles, conflict resolution, negotiation, active listening etc. ensures that these groups can contribute greater value to the chain.

HOW RANGELANDS AUSTRALIA SUPPORTS THE VALUE CHAIN

Rangelands Australia is a client-driven, knowledge-brokering unit developing educational packages to support the sustainability of rangeland enterprises and communities. The short course and post graduate programs are a response to market research which identified the immediate and long term needs of enterprises to be sustainable in the future. The courses have been developed through a participative process with a diversity of stakeholders with an interest in the rangelands. These processes have defined the skills and knowledge required in the key areas.

Courses are designed to develop the skills of lifelong learning and build knowledge to meet increasing complexity in rangelands management. They will also nurture the personal attributes identified (in the focus groups) as necessary to be successful in the rangelands in the long run (Taylor 2002). The Rangelands Australia attributes parallel those required for vibrant supply chains in the rangelands and include:

- commitment and passion for the rangelands
- sensitivity to other values and aspirations
- practical
- self confident
- adaptable
- positive attitude to change, and
- a willingness to learn.

The participative processes used by Rangelands Australia in the development of courses ensure collective wisdom and experience of contributors is utilised to meet current and future challenges for enterprises in the rangelands. Some courses are applicable to building knowledge throughout the chain while others focus on production, particularly emphasising sustainable production (Figure 2).

Rangelands Australia is working to overcome isolation issues for knowledge building in the rangelands by delivering its courses in the rangelands. Facilitators will deliver courses wherever there are sufficient numbers to form a quorum. Courses are designed to prepare participants for future change by including the skills of lifelong learning. Participants develop a knowledge of the 'know-why', 'know-who' and 'know-how' which, in the knowledge economy, are more important than the 'know-what' – facts that can change rapidly with global communication and technological capabilities (Ministry for Economic Development N.Z. 2001).

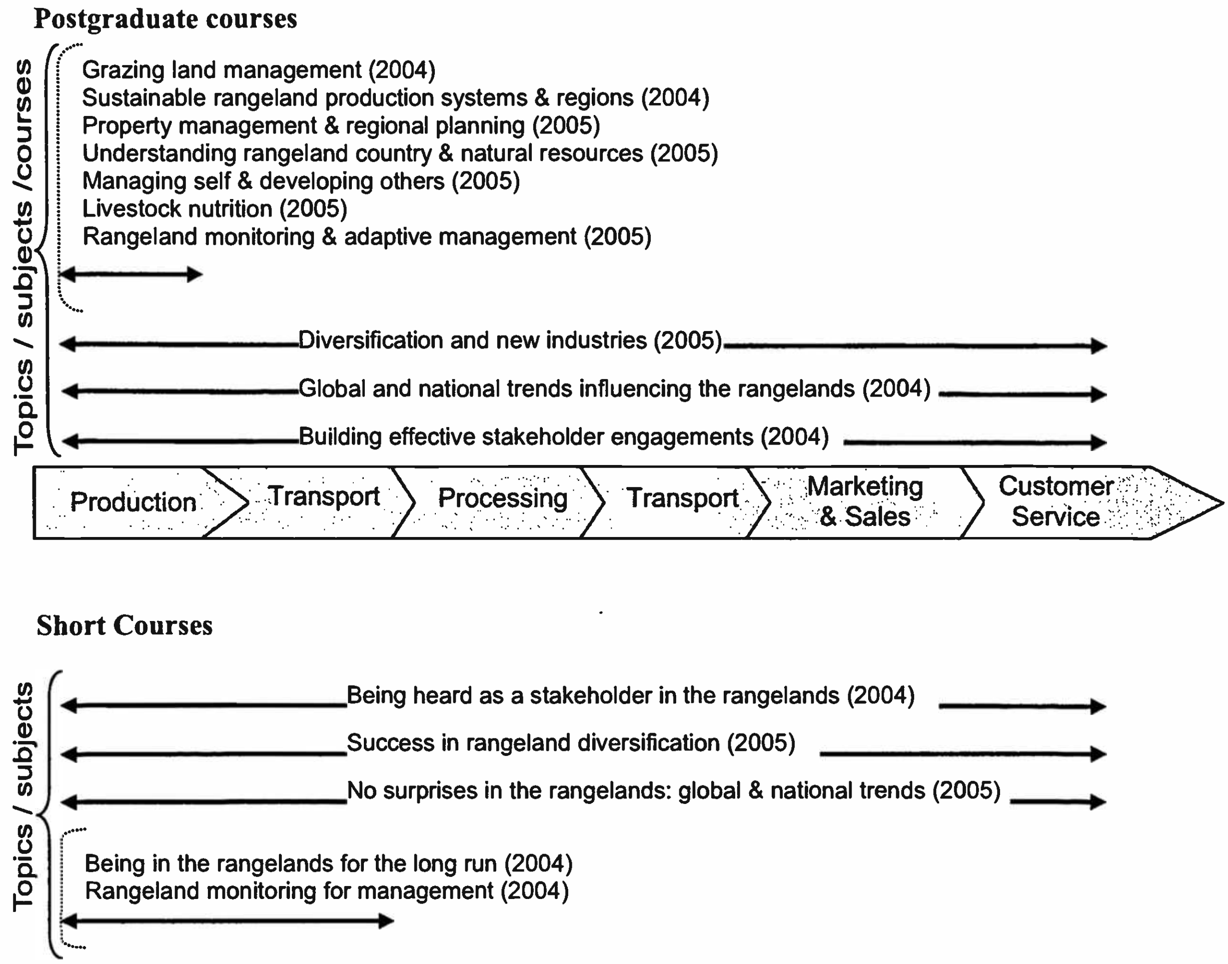


Figure 2. Rangelands Australia courses matched to the supply chain.

CONCLUSION

The future of the rangelands lies in the enterprises that can generate innovative ways of adding value to their supply chains to meet strategic social, environmental and economic goals. People and relationships underpin knowledge management, so investment in people is an investment in the future of the enterprises in the supply chain. A wise supply chain utilises stakeholders who can reflect on past experiences, review future trends and evaluate outcomes – in short, it is a chain that can access, use and evaluate information to generate its own knowledge and to serve its strategic purpose which, ultimately, is client satisfaction!

REFERENCES

Furlong, G. (2001). Knowledge management and the competitive edge. University of Greenwich Business School. http://www.gre.ac.uk/schools/business/Dissertation/ (accessed April 2004).

Georgia Tech, Economic Development Institute, Atlanta. http://www.edi.gatech.edu (Accessed April 2004).

Goldman, D., Boyatzis, R. and McKee, A. (2002). *The New Leaders: Transforming the art of leadership into the science of results.*

Guptara, P. (1998). Knowledge Management: Recognition and Reward in Knowing More than your Competitors: Putting Knowledge Management to Work. The Economist Conferences' 1998 Conference. London, 24-25 September 1998.

http://growth-strategies.com/subpages/businesswritings/015.html (accessed April 2004)

Lave, J. and Wenger, E. (1991). *Situated Learning: Legitimate peripheral participation.* Cambridge University Press.

Ministry for Economic Development, New Zealand (2001). What is the knowledge economy? http://www.med.govt.nz/pbt/infotech/knowledge_economy/knowledge_economy-04.html#P55_12865 (accessed April 2004).

Polanyi, M. (1966). *The Tacit Dimension.* Routledge & Kegan Paul, London.

Pór, G. (2000). 'Knowledge – Intelligence – Wisdom: Essential Value Chain of the New Economy' *delivered at* Consultation Meeting on the Future of Organisations and Knowledge Management of the European Commission's Directorate-General "Information Society Technologies" Brussels, 23-24 May 2000. http://www.co-i-l.com/coil/knowledge-garden/kd/kiwkeynotes.shtml (accessed April 2004).

Taylor, J.A. (2002). Key personal attributes and areas of knowledge for future success in the rangelands. Proceedings 12th Biennial Conference of the Australian Rangeland Society, September 2002, Kalgoorlie, pp 74-78.

Wenger, E. (2003). Module 1: Creating Value through communities of practice – or the doughnut of true knowledge management. Presentation for ANTA. www.shapingthefuture.net (accessed January 2004).

Wenger, E. (2003). Module 2: Organisational Initiative. Presentation for ANTA. www.shapingthefuture.net (accessed January 2004).

MAKING SUPPLY CHAIN MANAGEMENT WORK – ROBINS FOODS CASE STUDY

Juleigh Robins

Managing Director, Robins Foods Pty Ltd
Board Member, Indigenous Australian Foods Ltd
Board Member, Coles Indigenous Food Fund

ABSTRACT

A supply chain is more than an academic concept and a business model – it is a structure based on real companies and individuals co-operating with each other to bring real benefits to themselves and to each other. Supply chains are all about relationships – corporate and personal. To make a supply chain work trust needs to be developed between all partners in the chain. Managing a working, viable supply chain means that supply chain managers, and indeed supply chain partners, need to realign their thinking so that they are developing business for the chain – not just for their individual company within it. Real value for each supply chain partner must result.

A supply chain therefore must have very clear objectives that all partners commit to. It must ensure that at every level within it, chain partners feel that they are part of the whole – ongoing commitment to meaningful communication, co-operation and knowledge sharing are the keys to making supply chain management work.

Robins Foods have developed a unique supply chain that embodies these principals. This paper will describe our chain and how we've done it.

THE ROBINS/ INDIGENOUS AUSTRALIAN FOODS (IAF) SUPPLY CHAIN

Introduction

Robins Foods are a passionate advocate for the incorporation of Australian native food ingredients into the Australian and global food industry. Over the past three years Robins Foods and our chain partners have developed a native food supply chain with the following objectives:

- Provide equity for our Aboriginal partners in the supply chain.
- Ensure the long term economic and environmental sustainability of native foods supply to the supply chain.
- Ensure that the supply chain is demand pulled – not supply pushed.
- Establish Outback Spirit brand (umbrella brand) as the mainstream market leader for products featuring native foods.
- Establish Outback Spirit as a mainstream brand for the long term.

Robins/IAF unique supply chain provides equity in the chain to the company's Aboriginal Community suppliers and formally includes Coles Supermarkets as the chain's domestic retail partner and Hela International as the chain's export industrial ingredients partner.

The Robins/IAF Supply Chain has a flagship brand ***Outback Spirit***. Outback Spirit unites all chain members under a common brand and focus. Outback Spirit has pioneered the entry of native foods into the mainstream grocery category of supermarkets in Australia and overseas.

Outback Spirit has been developed as an **umbrella brand** and other food manufacturing companies, such as Kez's Kitchen, Cooka's Country Cookies, and Mariani Meats are value adding their ranges with native food flavours under the Outback Spirit license. Outback Spirit value-added foodservice products are widely used in the Australian hospitality foodservice market and Robins have licensed international ingredients manufacturer and marketer Hela International, to market their Outback Spirit range of value added native flavoured ingredients throughout Europe under the "Hela Outback Spirit" brand.

Success has been built on developing additional skills in business development and supply chain management to complement Robins company's directors' expertise in marketing and product development of these unique ingredients.

Sharing and equity along the chain:

The Robins Foods/IAF chain is very much about sharing and equity along the agribusiness chain:

1. Robins Foods supply chain ensures that our large base of Aboriginal community suppliers have meaningful inclusion in the native food industry by sharing equity in supply company *Indigenous Australian Foods.* IAF supplies exclusively to Robins Foods, and Robins Foods purchase all native foods exclusively through IAF. IAF brings real benefits to communities – economic (through sale of foods), social (training communities to value add raw material for supply and thereby creating skills and employment plus in a real sense of "ownership" of these products through endorsement) and cultural (helping preserve traditional Aboriginal skills and foods through commercialisation and inclusion of Aboriginal people in mainstream economic business).

2. Robins work closely with Coles Supermarkets to market and promote an "Australian" food category. Coles and Robins are partners in the *Coles Indigenous Food Fund* and 30 cents from the sale of each Outback Spirit product is contributed to the CIFF. This money is then used to assist Aboriginal communities develop further their native foods businesses. This fund directly assists Aboriginal people and provides all members of the chain including Coles, with benefits such as increased self esteem and improved staff morale.

3. Marketing the IAF endorsement has also brought further value to the chain and to the chain's **endorsed companies**. Companies included are Robins, Coles Supermarkets, Voyages Hotels and Resorts, Great Southern Rail and Kez's Kitchen, Cookas Country Cookies and Mariani Meats. Benefits for these companies are both tangible and intangible, and provide member companies with clear marketing opportunities (both product and corporate differentiation) and demonstrable good corporate citizenship. Benefit to the chain is increasing credibility of the endorsement through uptake by prestigious companies.

4. Companies under licence to Outback Spirit receive added value for their involvement by receiving support for the brand by Coles Supermarket, automatic IAF endorsement and the opportunity to add line extensions in existing markets with distinct product differentiation.

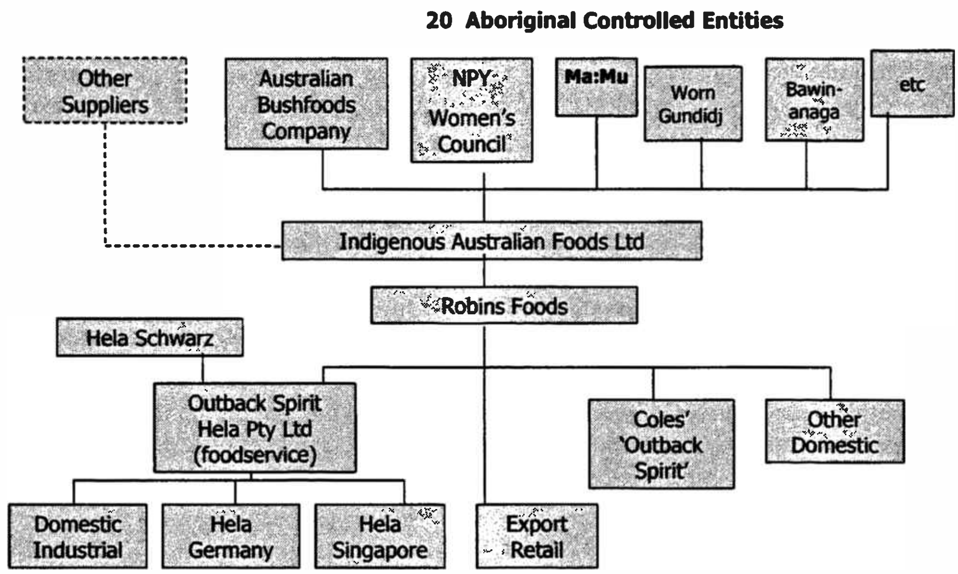
IAF Endorsement logo

Endorsed companies currently include Robins Foods, Kez's Kitchen, Cooka's Country Cookies, Mariani Meats, Voyages Hotels, Coles Supermarkets, Great Southern Rail and All About Bread.

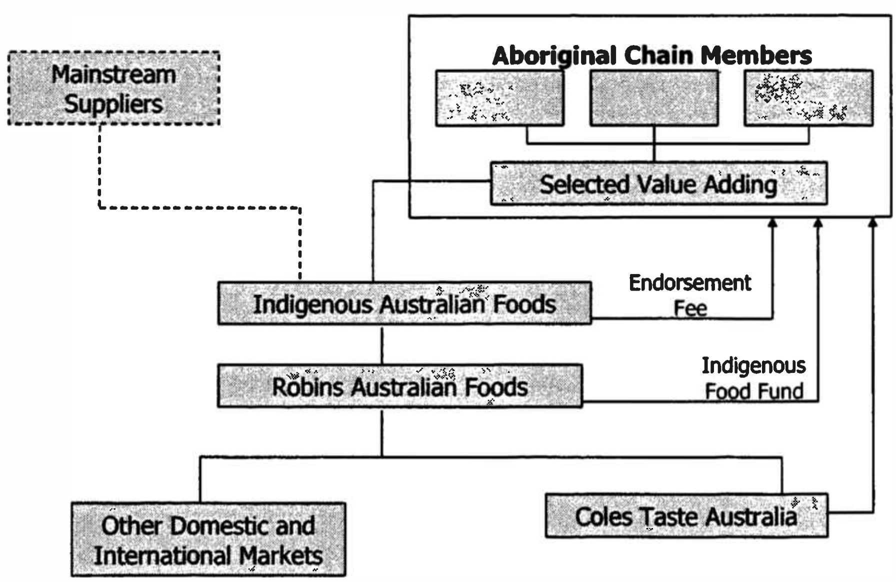
STRUCTURE OF THE ROBINS/IAF SUPPLY CHAIN

Our structure is shown in the following slides.

INDIGENOUS AUSTRALIAN FOODS SUPPLY CHAIN



Encouraging Indigenous Participation



Benefits in membership of Indigenous Australian Foods

- Assistance to supply (wild harvest or cultivation).
- Sale of products.
- Opportunity to value-add.
- Ownership of a product endorsement to be licensed to manufacturers.
- Proceeds of the endorsement fees to go back to communities.
- Participation in the Coles IFF.
- A long term involvement in taking traditional Aboriginal foods to the mainstream (right around the world).

Endorsement by Indigenous Australian Foods

- Approved companies may become endorsed by IAF Ltd. This endorsement will identify the products of the approved companies as including native foods that are the product of Aboriginal enterprise. The company will be able to declare that it is a financial supporter of Aboriginal enterprise.
- The benefits to endorsed companies are both tangible and intangible and will provide companies with clear marketing opportunities (both product and corporate differentiation) and demonstrable good corporate citizenship. Logos and other supporting promotional material will be available.

ENSURING THE CHAIN IS DEMAND PULLED

Robins Foods as the marketing arm of the chain has focussed on broadening demand for native foods across a number of target markets. Company sales have doubled over the past three years as a direct result of the development of the supply chain and Outback Spirit value added products. Similar future growth rates are forecast for the next three years. Reaching sales targets is critical for the chain in order to bring about "critical mass". The targeted markets are:

Mainstream Retail

The most significant growth has been in the mainstream grocery category of Coles Supermarkets where eight Outback Spirit products are ranged nationally. Entry into Woolworths is anticipated in the next financial year. The expansion of the Outback Spirit brand (under licence) into further supermarket categories has commenced.

Strategies for success in mainstream:

a) **Consumer trials** – the company trialled a number of products in the retail market, including Coles (in specialty foods category only) to determine consumer preferences. Successful products were then incorporated into the Outback Spirit range for national ranging and distribution.

b) **Robins brand development** culminating in the Outback Spirit brand reflects through image and labelling the unique elements of the native food ingredients that consumers want to know about – ingredient description, product description, where the native ingredients are from and the Aboriginal involvement in their provision to the company. Recipes are included on the label for further value to consumers.

c) **Adoption of IAF's endorsement.** Outback Spirit products clearly show the IAF logo that identifies these products as being produced "In partnership with Aboriginal Enterprise" – thus ensuring the consumer has a choice to purchase a native food product that has integrity and authenticity.

d) **Coles' "partnership" in chain development** is the most important aspect of all. Coles' support of our chain development, through mainstream listing and contribution of profits to the CIFF has been critical to the success of Outback Spirit products in the mainstream market. This successful partnership with Coles rests on mutually shared objectives (Aboriginal equity in the native foods industry and the resulting benefits going back to Aboriginal people) and the strength of the relationship built up between Robins, IAF and Coles Supermarkets.

Industrial Foodservice

Robins have licensed the Outback Spirit brand to a multinational ingredients company "Hela International". The successful launch of *Hela Outback Spirit* native food flavours for the industrial food manufacturing industry in Europe has brought immediate follow-on orders and native food ingredients now have a permanent place in Hela's long term marketing strategy. The products will be rolled out into the Asia Pacific region. This formal partnership will bring an increasing demand for native foods to the chain. A strong relationship has developed between Hela International, its Australian venture Hela Schwarz, Robins and IAF. Senior Hela board members have personally visited some member Aboriginal communities and pledged ongoing support to the chain. Additionally Robins have provided Hela with complete access to formulas and product development skills while legal agreements were being formulated. A significant trust has developed between all parties and the partnership will be for the very long term.

Export Retail

Export markets for Outback Spirit products in the UK and Europe have been established with good growth expected in the next financial year. Current UK clients include the major supermarket chain Sainsbury's plc.

Opening these significant markets delivers increasing opportunities for IAF and its supplier base (both indigenous and non-indigenous) to increase their sales to Robins. Selected plantings are underway to meet ongoing demand. Robins and IAF continue to research and develop better ways to maintain sustainable supply.

Developing these markets and ensuring all chain members are aware of developments across the chain is an ongoing task for the lead company, Robins Foods. Regular formal and informal communication (emails, phone calls, meetings etc) takes place and given the geographic distances involved (IAF), at considerable cost.

The chain has a number of sustainable competitive advantages:

Outback Spirit as an umbrella brand will continue to develop increasing brand awareness and Coles has identified Outback Spirit as "the definitive native food brand" in the marketplace.

1. The IAF endorsement will become increasingly recognised and valued as the endorsement that adds integrity and authenticity to value added native food products and as the endorsement of Aboriginal enterprise.
2. Unique and delicious flavours of native foods and the supply chain based on Aboriginal involvement and environmentally sustainable agriculture to deliver them is a distinct competitive advantage – and one that places Robins at the forefront of the native foods industry.
3. Robins' creation of a new food category – value added native foods – and Coles, Hela and other large companies' support and value of this ensures that our small company and chain is competitively advantaged in a playing field that normally would be closed to us.

Development of strategic alliances and partnerships

Robins has developed a number of powerful strategic alliances and partnerships that add value to all levels of the chain. Some of these alliances are with companies far, far larger than Robins so that we can use the strength of these companies to assist us fulfil the chain's long-term goals:

1. At the inbound supplier end between ourselves and our Aboriginal supplier base through the creation of IAF.
2. At the inbound supplier end between ourselves and various agricultural grower groups (assisting in species selection, growing and propagation information, etc) and including them, via IAF into our supply chain.
3. Partnering the Australian Museum in the FATE (Future of Australia's Threatened Ecosystems) program to bring about environmentally enhancing agricultural systems for landholders entering the native food industry.
4. Utilising production capacity of a larger food manufacturing company,-Jensen's Choice Foods – who manufacture the Outback Spirit brand for Robins under contract.
5. Licensing a significant international ingredients company, Hela International, to market our brand of foodservice products internationally.
6. Licensing other medium-sized Australian companies to produce and market Outback Spirit brand products.
7. The strategic alliance with Coles Supermarkets to create, support and market a new food category – Australian native foods, and to do this in a way that brings real benefits to Aboriginal communities by assisting the development of their micro-businesses based on native foods. Formal partnership of Robins and Coles Supermarkets with the Coles Indigenous Food Fund.

CONCLUSION

Robins / IAF supply chain is successful because it is an integrated and inclusive chain with an ethical base, that provides real equity and benefits for its members. All supply chain members have a real sense of "ownership" and are committed to ongoing chain development. The creation of Outback Spirit as an umbrella brand and the IAF endorsement ensures all partners are working co-operatively to develop business for the chain, while increasing individual companies' returns. The "ethical" basis of the chain – providing real equity and economic opportunities for Aboriginal members – has attracted significant commercial chain partners who are committed to all the chain's objectives.

MAKING SUPPLY CHAIN MANAGEMENT WORK - CASE STUDY OBE BEEF

Peter Schmidt

OBE Beef Pty Ltd, Birdsville QLD

ABSTRACT

The Queensland based Channel Country group of organic beef cattle producers was informally put together in 1996. The group was subsequently incorporated as OBE Beef Pty Ltd involving some 21 stations, 18 shareholders with a total certified area of about seven million hectares and 100,000 cattle. Initial marketing focused on Japan but since then company organic beef is marketed domestically and into the USA, and prior to the 2002 drought some product was supplied to the European Union market.

The OBE Beef company has a fully certified organic food supply chain from producer, to processing, to wholesaling and retailing outlets with relevantly certified transport sectors. Multilayed certifications have been established along with brand names and trade marks and the essential traceback methodology is in place. Sustainability is primarily ensured through the organic certification process. Marketing is greatly assisted by the imagery and uniqueness of the Channel Country environment. The biodiversity provided by some 250 plant species imparts a verified special taste to Channel Country beef which is a further marketing advantage to what is becoming a well recognised brand name.

FOR HEALTHY COUNTRY AND HEALTHY PEOPLE: INDIGENOUS LAND MANAGEMENT IN CENTRAL AUSTRALIA

Jocelyn Davies and Sandy Marty

Overview paper for the Indigenous Land Management session incorporating contributions written by Donald Fraser, Tim Hill, Frank Young, Lexie Knight, Nic Gambold, Meg Mooney, Veronica Dobson, Jenny Cleary, Jason Downs and Rodney Edwards.

BACKGROUND

Indigenous people have a very important place in the management of Australia's rangelands and this is highlighted by the location of this conference in Alice Springs. Contributors to this session, including David Ross, Director of Central Land Council, as keynote speaker and a panel of Indigenous land managers will show some of the diversity of Indigenous peoples' management of rangelands and its significance. This overview paper introduces contemporary issues in Indigenous land management in central Australia and the perspectives that speakers bring to this session.

Within a thousand kilometres of Alice Springs, about half the land is held by Indigenous people in freehold or leasehold ownership. On other lands in the region – pastoral leases, protected areas and Crown lands in townships such as Alice Springs – native title has achieved broad legal recognition. Though most Indigenous people struggle to realise any tangible benefit from this legal recognition, it has pushed 'mainstream' natural resource management institutions to slowly reform because they are now realising that they need to involve Indigenous people effectively.

This reform is a big task because mainstream Australian approaches to natural resource management have their origins in the legal fiction of 'terra nullius', which said Australia was 'no-one's land', made Indigenous peoples' customary law invisible to governments and settlers, ignored its significance for sustainable management of country, and destroyed much of its effectiveness. Mainstream institutions for natural resource management – such as planning processes, funding programs and information services – are slowly adapting to recognise Indigenous peoples. Reality today in central Australia is that Indigenous people are significant managers of country both in their own right and in partnership with other people and organisations. Nevertheless there is still a long way to go before legislation, funding sources, government and non-government services are all effective at providing the support that Indigenous groups need to rebuild their own governance institutions and achieve healthy people and healthy country. This session will feature some innovative efforts by Indigenous people, Indigenous organisations and other partners that are working towards healthy people and healthy country. It will also point to barriers that continue to affect progress to these goals.

Indigenous people are the poorest residents of rangelands, in terms of income, and indications are that their social and economic well being is declining in many respects. Indigenous populations are also the fastest growing population sector in remote Australia. The size of the non-Indigenous population in remote Australia declined between 1986 and 2002, but the number of Indigenous people increased by 23% since 1981. There are now 36,000 Indigenous people in desert Australia and the number of working age people is predicted to increase by 34% by 2016, presenting a huge challenge for development of livelihoods. Many Indigenous people travel frequently across large areas of the desert including moving between small settlements and larger towns such as Alice Springs to access urban based services. Mobility raises many issues about the demand for services and equitable and effective funding regimes (Taylor 2003).

On Aboriginal owned lands, living places include settlements of several hundred or more people sometimes from a variety of clan or language groups, and smaller family centred outstation or homeland communities. People live in these places because it is their country and their home, not because of the economic opportunities. The viability of these settlements worries government policy makers and Aboriginal leaders alike. Can Australia as a nation afford the economic cost of servicing these areas as living places? Alternatively, can the nation afford the social, economic and ecological costs of the current situation in which so very few Indigenous families who are living on country have chances of sustainable livelihoods? A further important consideration is that, as Altman and Whitehead (2003:1) point out, Indigenous owned lands are generally quite underpopulated for effective management of the land.

The economy of remote Indigenous communities can be characterised as a hybrid (Altman 2001) between customary sectors (such as hunting and gathering; exchange within extended families); government (such as government funded community employment programs and jobs in the community services sector; social security payments) and enterprise (notably arts and crafts). While jobs and enterprises are scarce on Aboriginal lands and income levels of Indigenous people are critically low, the existence of these lands and their resident populations nevertheless contributes significantly to the regional economy in remote Australia. Crough *et al.* (1989 and see Howitt *et al.* 1990) concluded that a third of the economy of Alice Springs is attributable to the presence of Aboriginal land and Aboriginal people, and it is likely that this proportion has increased steadily in the 15 years since that research, because Aboriginal populations, the area of Aboriginal owned land and Aboriginal arts and craft production have all increased. As well as the Aboriginal contribution to the flow of money in central Australia, Aboriginal lands are likely to contribute significantly to the flow of ecosystem goods and services in the region. These factors are not yet properly recognised in research directions or in policy responses (Altman and Whitehead 2003). Thus Aboriginal people who are now managing lands, natural and cultural resources, struggle for the resources they need to fund paid jobs, vehicles and other basic necessities that will enable their management to be effective.

The important contribution of traditional ecological knowledge to sustainable land management is now being widely recognised, influenced by the impetus of the Convention on Conservation of Biological Diversity, and the tangible outcomes demonstrated by collaborations between traditional knowledge holders and scientists (e.g. Baker *et al.* 1992, Pearson and Ngaanyatjarra Council 1997, Kennet *et al.* 1998, Horstman and Wightman 2001, Kwan *et al.* 2001, Nesbitt *et al.* 2001; Robinson *et al.* 2003). As indigenous people participate in a search for new livelihood opportunities that draw from their knowledge and skills, they are also very concerned about making sure that their own rights and opportunities to get economic benefit from their knowledge and from the natural and cultural resources of their country are safeguarded and not put at risk by research and other kinds of knowledge sharing. The research and policy community is also now coming to understand that improved economic outcomes in remote indigenous communities depend less on marketable resources and access to markets than they do on the effectiveness of indigenous governance institutions (Cornell and Gil-Swedberg 1995, Cornell and Kalt 2003, Dodson and Smith 2003). This effectiveness is itself influenced by outsiders' recognition of indigenous rights to self determination, and by the mechanisms that indigenous groups themselves use to achieve a balance between the benefits that group members realise from communally owned or managed resources and the effort those members put in to maintaining these resources. This kind of balance, existing under customary governance institutions, promoted sustainability (see Ostrom 1990, Rose 1997, Berkes 1999, McKean 2000).

At the same time as outsiders are coming to recognise the achievements of indigenous people in sustainable management derived from customary law and traditional knowledge, this knowledge and indigenous people's relationship to country is under greater threat than ever from ill-health and premature death in indigenous communities, changing priorities of indigenous youth attracting them away from traditional lands, and degradation of country through unmanaged fire, feral animals and human use.

How important is it to turn this situation around? The Indigenous land managers presenting in this session will talk about their positive initiatives and outcomes to address this situation, and why their efforts are important. They operate 'two-ways' in managing country, drawing from traditional knowledge, language and customary law and practices, and from partnerships with government agencies, other funding bodies, scientific researchers, and NGOs. Key issues for them include generating jobs in land management and getting income to cover their land management costs and to provide for their other economic needs. Other significant issues include: keeping traditional knowledge and language alive; protecting cultural values and customary knowledge of country and natural resources; and addressing threats to land rights, and to the realisation of Indigenous rights to self determination. 'Umbrella' Indigenous organisations and government agencies that provide land management support services play a significant role in supporting Indigenous people in contemporary management of country. Staff of several such organisations have worked with community members to develop this session[4].

KEYNOTE SPEAKER, DAVID ROSS

In opening the session, keynote speaker David Ross will draw from his experience as Director of Central Land Council and the significant responsibilities that entails under the Aboriginal Land Rights Act 1976 (NT) and the Native Title Act 1994 to promote the rights and interests of traditional owners in land management and land tenure across the southern part of the Northern Territory. Mr Ross' career has also spanned national responsibilities in indigenous land management as the founding chair of the Board of the Indigenous Land Corporation, a former ATSIC commissioner and Board member from the Northern Territory and a member of the task force responsible for developing the ATSIC & DPIE National Aboriginal and Torres Strait Islander Rural Industry Strategy (1997).

PANEL MEMBERS

A panel of Indigenous community based land managers from Ngaanyatjarra, Yankunytjatjara, Warlpiri and Arrernte countries in Western Australia, South Australia and the Northern Territory will talk about contemporary land management covering:

- Scope – What is happening?
- Significance – Why is this effort important?
- Successes – What has been working well, and why?
- Disappointments – What are the problems? What is not going well and why?

Panel members include:
Donald Fraser, Chair Uluru-Kata Tjuta National Park Board of Management
Frank Young, Director of Anangu Pitjantjatjara Yankunytjatjara Land Management
Tatjitjara Robertson, Ian Ward and Mr Richards of the Ngaanyatjarra lands
Neville Poulson of the Warlpiri community ranger group
Veronica Dobson from Tangentyere Council's Land and Learning project
George Cooley from the Aboriginal Lands Interim Natural Resource Management Group, South Australia.

The panel presentation will finish with discussion, offering opportunities for the conference to consider questions such as:

- How does Indigenous land management contribute to sustainability in the rangelands?
- How does land management link to community development and health, making it a holistic undertaking?
- What actions can other people take to support sustainable outcomes from Indigenous land management?
- How can livelihoods for indigenous people in land management and related areas be promoted?

---

[4] A further contribution to the conference's consideration of these issues comes from Northern Land Council - see Mark Ashley, Anita Hudd, Alistair Trier, Garry Richardson and Max Gorringe: *The Indigenous Pastoral Project: People achieving development, conservation and people outcomes,* Poster presentation at this conference. Further, Jocelyn Davies, *Engaging Indigenous partnerships* from CSIRO is a poster addressing considerations for effective research partnerships between scientists and Indigenous organisations/Indigenous land managers.

Donald Fraser is Chair of the Uluru-Kata Tjuta National Park Board of Management in the Northern Territory. Donald also operates a pastoral business based on agistment of cattle in the eastern part of the Anangu Pitjantjatjara Yankunytjatjara (APY) lands, north-west South Australia. His involvement in land management spans a very wide spectrum from balancing cultural values, mass tourism and biodiversity conservation in the World Heritage listed joint managed park at Uluru where he is a traditional owner, through to balancing pastoral use, commercial outcomes and cultural values of land in the APY lands on country where other people are traditional owners. His situation highlights the range of different kinds of relationships and responsibilities that Aboriginal people can have for managing country.

Donald Fraser works closely with **Tim Hill**, Central Land Council support officer for the Aboriginal owners of Uluru-Kata Tjuta National Park. Together they will talk on the topic of *Consulting with Traditional Owners regarding Land Management and Land Use proposals*.

Donald will discuss the term Nguraritja (traditional owner in Yankunytjatjara) and the Anangu (i.e. Yankunytjatjara-Pitjantjatjara peoples') system of land ownership and title. Tim will give a short overview of the relevant sections of the *Land Rights Act* (NT) 1976 and the history of missions and government communities in the south-west Northern Territory and north-west South Australia. Donald will talk about why some Aboriginal people live away from the country where they are traditional owners, and examples of consulting with traditional owners about land use.

Frank Young is Director of Anangu Pitjantjatjara Yankunytjatjara Land Management (APYLM) and a traditional owner at Waturu community and Indigenous Protected Area in the western part of the Anangu Pitjantjatjara Lands, north western SA. **Frank Young** and **Lexie Knight** (coordinator of APYLM) explain APYLM's role as follows:

> "The key aspiration of Anangu (Aboriginal people) for management of their land is strong, healthy families. In achieving this it is important that the people who hold the Tjukurpa (customary Law) for county are actually the ones doing the land management work.
>
> "Anangu Pitjantjatjara Yankunytjatjara Land Management (APYLM) brings voice to Anangu aspirations with regards to the stewardship of the land. This ensures continued economic engagement of Anangu with their land and that natural resources are managed in culturally appropriate, ecologically sustainable ways, drawing upon both traditional and contemporary expertise".
>
> "There is a synergy between the land management projects that APY facilitates and biodiversity outcomes, even though the starting point for APYLM is Tjukurpa and the aim is managing country for family, not for biodiversity. For example, rock holes in the Anangu Pitjantjatjara Lands are a key water source for many native animals. Cleaning rock holes has a major impact on biodiversity with minimal input. Patch burning stimulates the regeneration of sweet grasses and vegetable foods used by Anangu. Patch burning creates mosaics of vegetation that increase biological diversity. On Walalkara and Wataru Indigenous Protected Areas, Anangu use patch burning and rock hole cleaning to look after country. They look after country according to Tjukurpa (the Law)."[5]

Other land management projects in the AP Lands include harvesting wild camels to reduce grazing pressure and conflicts with people as well as for economic benefit, described in **Rick Hall** and **Lexie Knight**'s poster paper elsewhere in these proceedings.

---

[5] Frank Young & Alex Knight, *Manta Atamankupai. (Land Management) on the Anangu Pitjantjatjara Yankunytjatjara Lands,* Abstract submitted for ARS 2004 conference. Anangu Pitjantjatjara Yankunytjatjara Land Management, Umuwa via Alice Springs, NT, 0872 lmapy@bipond.com

Tatjitjara Robertson, Ian Ward and **Mr Richards** are Ngaanyatjarra men who live and work on their traditional Lands in the western desert region of Western Australia. Within the Ngaanyatjarra Lands there are two vast conservation reserves, namely the Gibson Desert Nature Reserve and the Ngaanyatjarra Indigenous Protected Area. In practical terms, both Reserves are very remote from mainstream support yet contain eight established communities with fully developed infrastructure and an available labour force. The Gibson Desert Traditional Owners balance their land management activities with cooperation and support for activities conducted through the WA Department of Conservation and Land Management. Adjoining the Reserve, the Ngaanyatjarra Indigenous Protected Area provides for a contribution of Commonwealth government resources to support conservation outcomes. As with the Gibson Desert Nature Reserve, the Ngaanyatjarra IPA is unique in providing an area of unbroken continuous occupation and traditional land management. The biodiversity resulting from this management includes significant populations of endangered species. Through the continued practice of traditional management and linkages with mainstream conservation programs, the Ngaanyatjarra are ensuring the survival of these species and the integrity of the associated bioregion. These three men have been instrumental in the development and focussing of the Ngaanyatjarra Council Land Management Unit on cultural and conservation outcomes. This presentation complements poster papers at this conference by other Ngaanyatjarra contributors: **Mrs Giles, Mrs Davies and Matjuwa Jones** from Patjarr with **Madeline Hourihan** on management of Tjakura, (*Egernia kintorei*, Great Desert Skink) and by **Daisy Ward** and **Rodney Edwards** on the Land Management Education Continuum which is promoting inter-generational transmission of traditional ecological and cultural knowledge.

Neville Poulson is a Warlpiri man and a community ranger in the newly established Warlpiri land management unit which operates in the southern Tanami desert, north-west of Alice Springs. The group is involved in developing collaborative management with Birds Australia for Newhaven Gap bird sanctuary, in biological survey in association with Newmont's Granites and North Flinders Mines, and in a feasibility study for the management of the Tanami Region as an indigenous protected area. Neville works closely with **Nic Gambold** of the Central Land Council Land Management Unit. Their efforts in establishing this new Indigenous land management service highlight some of the strategic issues involved in resourcing Indigenous Land Management in Australian rangelands. Nic Gambold explains the context for their collaboration as follows:

> "Indigenous land management (ILM) is an expanding initiative on Aboriginal lands throughout Australia. Given its potential to deliver significant socio-economic as well as environmental benefits, it is a highly advantageous community-based activity. Moreover, when considered in relation to its prospective extent (e.g. *c.* 820,000 sq km for Aboriginal freehold lands in the NT) imperatives for its wider instigation and support are clear.
>
> "As a result of collaboration between Aboriginal land owners, land councils, government agencies, tertiary education institutions and the Tropical Savannas CRC, savanna-based ILM groups have been relatively well supported in recent years. Multi-agency cooperation in the Top End has lead to a semi-formalised support network, the North Australian Indigenous Land and Sea Management Association (NAILSMA). This and the development of broad, strategic funding approaches have allowed the indigenous ranger movement in the tropical north to flourish. Conversely, ILM in Central Australian has been slow to emerge. Support has been limited and discrete. Few formal structures exist and most community-based ILM 'programs' are little more than a series of disjunct land-based projects. In this context there have been few opportunities for training, capacity building or the development of impetus within or between communities.
>
> "However, sweeping reforms occurring across the NT, for example the hand-back of Territory parks and reserves to traditional owners, prescribe a vastly increased expectation of Aboriginal traditional owners, and their representative agencies, to manage their land for conservation benefit. Increased levels of responsibility for these, essentially private, landowners clearly justify far greater public investment in ILM. This focuses attention on developing options for a more

strategic approach to supporting, resourcing and promoting Aboriginal land care in the southern NT." [6]

Veronica Dobson is on the steering committee of Tangentyere Council's Land and Learning project, which focuses on teaching the land managers of tomorrow. Tangentyere is an Aboriginal organisation that supports Aboriginal management of 18 town camps within Alice Springs and their resident and mobile visiting populations from across the southern Northern Territory. Tangentyere runs a major community development employment program and associated training and is a job network provider. Its land management section supports projects on Aboriginal lands across the southern Northern Territory, including propagation and bushcare activities. Tree-planting activities will be highlighted by **Kevin Ronberg**'s poster presentation at this conference. **Veronica Dobson** and Land and Learning project officer **Meg Mooney** describe the Land and Learning project as follows:

> "Young Aboriginal people need to learn about managing country from their elders. They also need to learn about western land management theory and practice. Two-way education in land management will equip interested young people to carry on the work of their elders and make future decisions about their land. Ideally this education will link in with employment and training opportunities in parks and elsewhere.
>
> "Tangentyere's Land and Learning project has been developing a land management education program for children in central Australian Aboriginal communities for a number of years. This program has received enthusiastic feedback from students, teachers and community elders, and the NT Education Department.
>
> "We work through schools, doing activities for at least a few days a term with each of the schools we work with, and providing teachers with preparation and follow up activities and resources. The idea is for there to be ongoing learning, rather than a once-off exercise. With community elders we teach children about the animals and plants in their country and contemporary land management issues such as the decline of native species, feral animals and weeds.
>
> "There are often one or two children in a class who are outstanding in their interest and/or knowledge of a particular topic. It may be useful to develop a mentoring program for these children, linking them in particular with training and employment opportunities in the area.
>
> "Land and Learning has developed a 90 page two-way activities book, based around the themes of animals, plants, water, fire and tools. The book is now an official resource of the NT Curriculum Framework, and is widely used by Education Department resource staff and community schools.
>
> "We have found that working through schools is an efficient way of using our resource, builds capacity in indigenous teachers, and models the value of involving community elders to non-indigenous teachers.
>
> "We are planning to extend our activities by working with NT Parks and Wildlife staff on junior ranger activities, and involving indigenous students in animal survey work on parks. Parks and Wildlife and Central Land Council are interested in the Land and Learning model in relation to education and training provisions for the agreements they are developing for joint management of parks." [7]

---

[6] Gambold, Nic (2004). *Strategic Resources for Indigenous Land Management in the Central Land Council Region*, Abstract submitted for ARS 2004 conference. Land Management Section Central Land Council, Alice Springs. Ph (08)8950 5008.

[7] Dobson, Veronica and Mooney, Meg. (2004). Teaching the land managers of tomorrow. Abstract submitted to 2004 ARS conference. Tangentyere Council, Alice Springs. Ph 08 8952 8029.

George Cooley is an Aboriginal community leader from Coober Pedy and member of the Aboriginal Lands Interim Natural Resource Management Group for South Australia. George has a strong interest in community sustainability, including recent involvement with planning processes undertaken with Rural Solutions SA to develop community sustainability in a holistic sense, looking at environmental, social and economic outcomes. **Jason Downs** and **Jenny Cleary** of Rural Solutions SA describe this planning further, as follows:

> "Rural Solutions SA has been working on holistic planning processes with Indigenous Communities and groups across South Australia, including several in the rangelands. The outcome from the work with each group is a 'plan' for long term sustainability, which considers social, environmental, economic and cultural impacts, and most importantly, is determined by the community. Such a plan enables communities and groups to be much more directive in their dealings with government and non-government agencies, from a basis of sound decision making that is wholly owned by the community as the decision makers."
>
> "Participants are encouraged to view their situation as a continuum and to plot their current and preferred futures. Requirements for training and development naturally fall out of such a process and support the vision for development of the community rather than what tends to happen currently, where training often occurs in complete isolation of any planning by the community. Often the outcome of training isolated from community development is highly trained people with technical skills but with no real job prospects or potential to use the skills in the community because there is no appropriate enterprise or infrastructure to support a suitable enterprise." [8]

REFERENCES

Altman, J.C. (2001). *Sustainable development options on Aboriginal land: The hybrid economy in the twenty-first century*. CAEPR Discussion Paper 226/2001. Centre for Aboriginal Economic Policy Research, ANU, Canberra.

Altman, J. and Whitehead, P., (2003). *Caring for country and sustainable Indigenous development: Opportunities, constraints and innovation*. CAEPR Working Paper 20/2003. CAPER, ANU, Canberra.

Baker, L., Woenne-Green, S. and community, M. (1992). The role of Aboriginal ecological knowledge in ecosystem management. *In* Aboriginal Involvement in Parks and Protected Areas, Birckhead, J., De Lacy, T. and Smith, L., Eds. Aboriginal Studies Press. Canberra: 65-73.

Berkes, F. (1999). *Sacred ecology: Traditional ecological knowledge and resource management*. Taylor and Francis, Philadelphia.

Cornell, S. and Gil-Swedberg, M. (1995). Sociohistorical factors in institutional efficacy: economic development in three American Indian cases. *Economic Development and Cultural Change* 43: 239-68.

Cornell, S. and Kalt, J. (2003). *Alaska native self government and service delivery: what works?* Native Nations Institute for Leadership, Management and Policy, University of Arizona.

Crough, G.J., Howitt, R. and Pritchard, B. (1989). *Aboriginal economic development in Central Australia : a report for the Combined Aboriginal Organisations of Alice Springs*. Combined Aboriginal Organisations of Alice Springs, Alice Springs, N.T.

Dodson, M. and Smith, D. (2003). *Governance for sustainable development: Strategic issues and principles for Indigenous Australian communities*. CAEPR Discussion Paper 250/2003.

[8] Downs, Jason and Cleary, Jenny (2004). Community sustainability – a continuum? Abstract submitted for ARS 2004 conference. Rural Solutions SA, Primary Industries and Resources, 12 Tassie St, PORT AUGUSTA SA 5700; ph 08 8648 5160

Horstman, M. and Wightman, G. (2001). Karparti ecology : recognition of Aboriginal ecological knowledge and its application to management in North-Western Australia. *Ecological Management and Restoration* 2: 99-109.

Howitt, R., Crough, G. and Pritchard, B. (1990). Participation, power and social research in Central Australia. *Australian Aboriginal Studies* 1(3): 2-10.

Kennet, R., Mununguritj, N. and Yunupingu, D. (1998). The Dhimurru Miyapunu Project. *In* Marine Turtle Conservation and Management in Northern Australia. Kennet, R., Webb, A., Guinea, G. and Hill, G., Eds. Centre for Indigenous Natural and Cultural Resource Management and Centre for Tropical Wetlands Management. Darwin: 69-75.

Kwan, D., Dews, G., Bishop, M., & Garnier, H. (2001). Towards Community-Based Management of Natural Marine Resources in Torres Strait. *In* Working on Country: Contemporary Indigenous Management of Australia's Lands and Coastal Regions. Baker, R., Davies J., & Young, E., Eds. Oxford University Press, Melbourne: 214-230.

McKean, M. A. (2000). Common property: what is it; what is it good for; what makes it work? *In* People and forests: communities, institutions and governance. C.C. Gibson, M.A. McKean and E. Ostrom, Eds. MIT Press, Cambridge, Massachusetts: 27-56.

Nesbitt, B., Baker, L., Copley, P., Young, F. and Anangu Pitjantjatjara Land Management (2001). Co-operative Cross-cultural Biological Surveys in Resource Management: Experiences in the Aṉangu Pitjantjatjara Lands. *In* Working on Country: Contemporary Indigenous Management of Australia's Lands and Coastal Regions. Baker, R., Davies J., & Young, E., Eds. Oxford University Press, Melbourne: 187-198.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge University Press, New York.

Pearson, D. and Ngaanyatjarra Council (1997). Aboriginal involvement in the survey and management of rock-wallabies. *Australian Mammalogy* 19: 249-256.

Robinson, A.C., Copley, P.B., Canty, P.D., Baker, L.M. and Nesbitt, B.J. (2003). *A biological survey of the Aṉangu Pitjantjatjarà lands, South Australia. 1991-2001.* Biodiversity Survey and Monitoring Section, Department for Environment and Heritage, Adelaide.

Rose, D.B. (1997). Common property regimes in Aboriginal Australia: totemism revisited. *In* The governance of common property in the Pacific Region. Lamour, P., Ed. National Centre for Development Studies, Australian National University. Canberra: 127-144.

Taylor, J. (2003). Population futures in the Australian Desert, 2001-2016. *Australian Geographer*, 34:355-370.

BIODIVERSITY MONITORING IN RANGELANDS

Craig D. James

CSIRO Sustainable Ecosystems and Desert Knowledge CRC
PO Box 2111, Alice Springs, NT 0871. Craig.James@csiro.au

ABSTRACT

The potential users of biodiversity monitoring tools and techniques have substantial constraints such as time and money, and so they require structured guidance on how to proceed in developing monitoring programs. I review the meaning of "biodiversity monitoring" and the usefulness of tools and techniques for monitoring biodiversity. I conclude that the practical application of resources to monitoring requires answers to the following questions: Why do people need to monitor biodiversity? At what scales and resolutions of data capture do they need biodiversity monitoring information? How can one identify the minimum and necessary set of attributes to measure within a biodiversity monitoring program? Techniques and protocols for scientific experimentation are different to those needed for monitoring, and scientists have a considerable challenge ahead of them to metamorphose scientific investigation techniques into monitoring tools and techniques that meet the specifications of groups wishing to apply them more widely.

INTRODUCTION

In striving to enact intent of sustainable use of natural resources, state government agencies and land managers face the problem of reifying the abstract term 'biodiversity', but also how to measure it so that long term detrimental trends can be detected and remedied in time. The term "biodiversity monitoring" has a series of hidden assumptions and questions: (1) that some element of it can be measured; (2) that those elements of biodiversity that could be measured will have broader meaning and appeal; (3) that measurement of those elements of biodiversity through time will yield trends of some sort; (4) that those trends could be changed if so desired; and (5) that there exists enough resources to devote to the activity of monitoring. An additional and most important assumption is that there is enough of an imperative for the results of monitoring to make the exercise necessary or worthwhile.

By it's very nature, biodiversity is a complex and multifaceted concept. The origin of the concept has only arisen in the last ten years, and it did so because of a dawning realization of the slow decline in the health of natural systems around the world: no one measurement of the natural world lead to an understanding of how biodiversity was declining. Therefore, it isn't realistic to expect one can monitor biodiversity by measuring a few, or even several hundred different aspects of the natural world. A more precise and concrete approach needs to be taken.

Biological scientists have developed a wealth of techniques for measuring different aspects of the environment. These can be techniques that directly assess the size or health of populations of particular species (e.g. counting endangered species), or techniques that measure threats to biodiversity (e.g. feral predator populations). Many of the techniques in use have been developed to answer specific questions of scientific investigation and are not necessarily transposable directly to biodiversity monitoring because they are, for example, too complex or not reliable.

As a result of an expert workshop in 2002 (Smyth *et al.* 2003; Smyth and James 2004), a comprehensive list of biodiversity monitoring techniques and indicators for rangelands were compiled. While the list of tools and techniques are all useful for scientific investigation, the need for biodiversity monitoring is no longer the sole domain of scientists. Community NRM groups, individual enterprises and governments are all calling for information on what to monitor and how to monitor it to be able to report on status and trends in "biodiversity". The results of the workshop offer prospective monitorers a shopping list from which to choose, but not necessarily a framework for which indicators or techniques are appropriate to their needs. In this paper I propose a conceptual framework for the organisation of the shopping list of techniques into subsets that are useful for particular purposes.

KNOW YOUR AUDIENCE

The reasons **why** biodiversity monitoring might be undertaken can be boiled down to two categories: (1) inform management; and (2) showcase good performance (to the market or for legislative compliance). The focus of each one is different and therefore has implications for what is required (Table 1). The first step is to critically analyse why you need to monitor and what information your audience requires.

Table 1. Key attributes of a biodiversity monitoring program depending on reasons for doing it.

INFORM MANAGEMENT	SHOWCASE PERFORMANCE
Detect and adjust for land use impacts that would have a negative effect on biodiversity and lead to reduced performance. *E.g. retain pasture grasses; manage visitor pressure; etc*	• Key legislative requirements • Key market sensitivities to biodiversity *E.g, management sympathetic to the maintenance of particular species/habitats; outcomes of rehabilitation; low impact use of natural resources; etc*

KNOW YOURSELF

The second filter for selecting potential biodiversity monitoring techniques from the shopping list (Smyth *et al.* 2003) is to specify what scale of information **you** require and what resources are available (time and money). A matrix of potential rangeland groups who might undertake some sort of biodiversity monitoring and the scale at which they require information is shown in Table 2. The sorts of information that would be useful to different groups with an interest in biodiversity (or any other) monitoring will be different depending on the resources they have available, and the reasons why they are monitoring (Section 1).

Table 2: Scales at which biodiversity monitoring data may be collected and be useful for different interest groups.

Group	Local scale (m^2, ha, km^2, paddock, property, reserve, local community and surrounds)	Regional (1000 km^2, catchment, NRM region, bioregion)	National (10000 km^2, state, nation)
Pastoral	•		
Local govt	•		
Indigenous	•		
Mining	•		
Tourism	•		
NRM groups	•	•	
State govt	•	•	
Federal govt		•	•

DEFINE WHAT YOU ARE MONITORING

Biodiversity is a shorthand way of expressing the phrase "biological diversity"; this is the variety of species and ecosystems, the interactions among and between these and their genetic diversity (e.g. Department of Environment Sport and Territories 1996). The concept of biodiversity grew relatively recently out of the slow realization of the collapse of the natural systems due to many pressures.

Natural systems are complex and the pressures on them causing disintegration are many, therefore, no simple view of the measurement of natural systems can summarise the problems and solutions.

When people talk of measuring biodiversity they often mean measuring some aspect of biodiversity like the number of species, the number of endemic species (species found only in that location), the types of species present (e.g. National Land & Water Resources Audit 2002). Given that biodiversity is about the variety of life, not the shear abundance of life, measurements of the number of individuals are misguided.

Different elements of biodiversity are chosen by different people to represent perspectives of biodiversity. For example, measurements of the number of species or size of populations of perennial plants and birds are frequently used to indicate the status of biodiversity. Others argue that invertebrates have to be measured because these make up the majority of species. Despite a lot of research it is clear that measurements of one species or group of species have little relevance to the trends and status of other groups of species (Abensperg-Traun *et al.* 1996). The question therefore is, what is the set of different things to measure that adds up to a credible picture of how healthy the environment is?

An analogy for this, that we accept in everyday life, is financial indicators. We know that no one indicator (e.g. Consumer Price Index, interest rates, different stock exchange indices, etc) tells us how the economy is going, and that analysts must look to a range of different ones to assess economic health. So too with biodiversity, a number of different aspects of it need to be examined to ascertain status and health.

My approach is to select at least one aspect of each of **three** elements of biodiversity (following Franklin *et al.* 1981, Noss, 1990): structural (e.g. appropriate age classes); compositional (e.g. species present); and functional (e.g. ecological processes are maintained). In addition, these aspects of biodiversity can be measured directly or via a pressure or threat surrogate such as land clearing. A balanced monitoring program across these structural aspects and targetting some response variables and some pressure/threat variables is desirable and will vary depending on circumstances as outlined in steps 1 and 2 above.

Table 3. Selected examples of a suggested necessary and sufficient set of elements to give a credible overview of the status and health of biodiversity.

Type of response	**Example monitoring group**	Structural	**Compositional**	**Functional**
Response of biota	Pastoral enterprise for **management feedback**	*Woody shrub distribution and abundance, especially noting where large numbers of new recruits are growing*	*Suite of palatable grass species are maintained*	*Patchiness caused by grass and shrub clumps is retained to capture and hold water and nutrients in the landscape*
Pressure or Threat to biota	State government conservation agency for **State of Environment reporting**	*Connectivity and fragmentation of patches in landscape is not getting worse*	*Key threatened species and threatened ecosystems are maintained or increasing*	*Disturbance processes are heterogeneous and at appropriate scales frequencies and intensities.*

HOW TO MONITOR

The OED defines the word '**monitor**' (verb) as "*To observe, supervise, or keep under review; to keep under observation; to measure or test at intervals, esp. for the purpose of regulation or control.*" Monitoring is done to detect *changes* through *time*. In terms of the natural environment this might be variation in the number of individuals present, the arrival of a new species, the loss of a species that has been present in the past etc. All monitoring has the implicit assumption that the measurement being taken is reliably able to detect some sort of change between times. While this sounds trite, in rangelands, we often find that measurements of plants and animals record fluctuations through time, but do these relate to changes induced by land use or pressure on some biota or just natural variation? While there does exist a number of techniques that are suitable for reporting change in some aspect of biodiversity in relation to land uses (e.g. remote sensing – Bastin *et al.* 1993, Ludwig *et al.* 2004), other techniques and indicators are still under scrutiny (e.g. ants – James 2004, Andersen *et al.* 2004). Some critical aspects of the techniques that are chosen are:

- ***objective repeatability:*** different people may be involved in measuring the chosen trait at different times and the results need to be independent of individual variation. Techniques should be developed that minimise training time for new observers and maximise simplicity and repeatability;
- ***reliable re-countability:*** the things being measured must be able to be measured each time. Many animals have an inactive stage during periods when the environmental conditions aren't favorable. Taking an extreme example of frogs, counting them during normally dry years (when the counts might be consistently zero) doesn't tell you anything about how many of them are actually alive and well under the ground. Birds can't go through stages of inactivity like frogs do, and so if they are alive and present they should be visible. However, birds raise another problem because some of them are migratory or nomadic and their absence at certain times shouldn't necessarily be taken as a sign of a problem.
- ***informative:*** if there are differences in the measurements between times, the information must be able to tell a reliable story of how things have changed and hopefully give some inkling of why they might have changed (but not always possible). Some background knowledge of the aspects being measured is almost certainly needed to make good interpretations.

According to the definition of monitoring, it does not include any suggestion of inferring the reasons why something might be changing through time. That is, monitoring might detect a correlation of things changing in some related way through time but it does not mean that it can attribute causation. Attributing causation between factors is the foundation of the scientific method and hypothesis testing (Underwood 1997), which occupies the pages of dozens of books. Most monitoring schema are not robust enough to detect these sorts of relationships and should not mistakenly be used in such a way. They can however be used to generate observations from which hypotheses and experiments are derived.

WHERE TO MONITOR

Having filtered the shopping list of potential indicators, and techniques to monitor those indicators (Smyth *et al.* 2003), down to a smaller set by making decisions outlined above, there remains an extremely difficult question of just where to do things on the ground to get the most effective result. The aims of monitoring will almost certainly mean that the results desired are different for each situation, and therefore the location of where and how it is implemented will be different. For some indicators, the location of monitoring is very simple (e.g. you monitor threatened species where they occur). For other indicators, sampling locations are not easily sited – as yet, there just isn't enough knowledge to know the most effective ways to use some techniques to get reliable, informative, and timely information about changes in the natural environment. For example, you could measure the abundance and health of pasture plants in an area of 10 m by 10 m. If you wanted to know about when to adjust stocking rates in a paddock to preserve forage resources you might make these measurements a kilometer or two from a water point where (arguably) threshold changes are most likely to be detected. If you wanted to know that long-term persistence of the native grasses was guaranteed, or that seed stores were still being generated for dry times you might make the same measurements 5-10 kilometers from a water point.

It is not possible to make any more prescriptions in this paper on how and where to use particular monitoring techniques because they will have to be customized for each implementation. However, there is a need for rangelands scientists to devote some time and effort to developing better *monitoring* techniques than are currently available to the range of land users.

EXAMPLE APPLICATION

Using the framework outlined above, it is possible to select a subset of indicators and techniques that could ***potentially*** be used in different circumstances. To illustrate this, Table 4 shows the subset that could be selected for relevance to a pastoral enterprise with low levels of resources (time or money) available. Within this there are some techniques that are relevant only to management feedback, and others to showcase performance. It is not intended that everything in this subset be done, but that it gives a reduced and targeted set of potential activities to select from. The detailed explanation of each indicator and how the 'Techniques' are applied is not shown due to space limitations but of course could be available as additional layers of information associated with the particular selections.

Table 4. Set of potential indicators and techniques that could be used by a pastoral enterprise with low levels of resources to monitor different aspects of the natural environment.

Reason for monitoring	Aspect of biodiversity measured	Indicator type	Indicator	Technique	Attribute measured	Variables recorded
Management feedback; Showcase status	Function; Structure	Pressure or threat	Average stocking rates	stocking rate	grazing pressure	density of stock
Management feedback	Composition	Pressure or threat	Distribution and abundance of feral animals	plot or transect count of species - scat counts	Feral animal - grazers	species ident and count
Management feedback; Showcase status	Composition	Pressure or threat	Distribution and abundance of feral animals	landholders' returns and records	Feral animal - predators	species ident and count
Management feedback	Composition	Pressure or threat	Distribution and abundance of feral animals	plot or transect count of species - spotlight	Feral animal - predators	species ident and count
Management feedback; Showcase status	Composition; Structure; Function	Pressure or threat	Distribution and abundance of invasive weed species	plot or transect count of species	weeds - terrestrial	species ident and count
Management feedback; Showcase status	Composition; Structure; Function	Pressure or threat	Distribution and abundance of invasive weed species	plot or transect count of species	weeds - aquatic	species ident and count
Management feedback	Composition	Pressure or threat	Localized grazing pressure on special assets	plot or transect count of species - scat counts	grazing pressure	species ident and count
Management feedback; Showcase status	Composition; Function	Response	Change in composition of bird fauna	plot or transect count of species	birds - terrestrial	species ident and count
Management feedback	Composition; Structure	Response	Change in composition of	photopoints	vegetation - terrestrial	species ident,

			perennial terrestrial vegetation			count, height
Management feedback	Structure; Function	Response	Change in composition of perennial terrestrial vegetation	plot or transect count of species	weeds - terrestrial	species ident and count
Management feedback; Showcase status	Composition; Function; Structure	Response	Change in composition of perennial terrestrial vegetation	plot or transect count of species and demography	weeds - terrestrial	species ident and age class
Showcase status; Management feedback	Composition; Structure	Response	Change in composition of perennial terrestrial vegetation	plot or transect count of species and demography	vegetation - terrestrial	species ident and age class
Management feedback	Structure; Composition	Response	Change in cover and structure of perennial terrestrial vegetation	photopoints	vegetation - terrestrial	species ident, count, height
Management feedback	Composition; Structure; Function	Response	Change in cover and structure of perennial terrestrial vegetation	plot or transect count of species and demography	vegetation - terrestrial	species ident and age class
Management feedback	Composition; Structure	Response	Change in cover and structure of perennial terrestrial vegetation	plot or transect count of species	vegetation - terrestrial woody shrubs	species ident and count
Management feedback	Structure; Composition	Response	Change in cover and structure of perennial terrestrial vegetation	photopoints	vegetation - terrestrial	species ident, count, height
Management feedback	Function; Structure	Response	Change in patchiness indicating loss of function	photopoints	vegetation - terrestrial	species ident, count, height
Management feedback; Showcase status	Composition; Structure	Response	Infrastructure to protect special assets	development of infrastructure or regime to protect assets from pressures	threatened species/ ecosystems	km new fencing, fire breaks etc

SUMMARY AND CONCLUSIONS

I have attempted to develop a decision framework in which subsets of potential tools for monitoring aspects of biodiversity could be selected to meet different users needs and resource availability.

ACKNOWLEDGEMENTS

Much of this material is synthesized from enjoyable discussions with colleagues Mark Stafford Smith, Anita Smyth and Melinda Hillery. I also thank all of those who attended the Expert Technical Biodiversity Monitoring Workshop in Alice Springs in September 2002 for their brilliant contributions to this difficult topic.

REFERENCES

Abensperg-Traun, M., Arnold, G.W., Steven, D.E., Smith, G.T., Atkins, L., Viveen, J.J. and Gutter, M. (1996). Biodiversity indicators in semi-arid, agricultural Western Australia. *Pacific Conservation Biology* 2: 375-389.

Andersen, A.N., Fisher, A., Hoffmann, B.D., Read, J.L. and Richards, R. (2004). Use of terrestrial invertebrates for biodiversity monitoring in Australian rangelands, with particular reference to ants. *Austral Ecology* 29: 87-92.

Bastin, G., Sparrow, A.D. and Pearce, G. (1993). Grazing gradients in central Australian rangelands: ground verification of remote sensing-based approaches. *Rangeland Journal* 15: 217-233.

Department of Environment Sport and Territories (1996). *The National Strategy for the Conservation of Australia's biological diversity*. Dept. Environment, Sport and Territories, Canberra.

Franklin, J.D., Cromack, K. and Denison, W. (1981). Ecological characteristics of old-growth Douglas-fir forests. USDA Forest Service General Technical Report PNW-118. Pacific North-west Forest and Range Experiment Station, Portland Oregan.

James, C.D. (2004). Trapping intensities for sampling ants in Australian rangelands. *Austral Ecology* 29: 78-86.

Ludwig, J.A., Tongway, D.J., Bastin, G.N. and James, C.D. (2004). Monitoring ecological indicators of rangeland functional integrity and their relationship to biodiversity at local to regional scales. *Austral Ecology* 29: 108-120.

National Land and Water Resources Audit (2002). *Australian Terrestrial Biodiversity Assessment 2002*. Commonwealth of Australia, Canberra.

Noss, R.F. (1990). Indicators for monitoring biodiversity: a hierarchical approach. *Conservation Biology* 4: 355-364.

Smyth, A., James, C.D. and Whiteman, G. (2003). *Biodiversity monitoring in the rangelands: A way forward*. Environment Australia and CSIRO, Alice Springs.

Smyth, A. and James, C.D. (2004). Key design issues for monitoring biodiversity in Australia's rangelands. *Austral Ecology* 29: 3-15.

Underwood, A.J. (1997). *Experiments in Ecology: Their Logical Design and Interpretation Using Analysis of Variance*. Cambridge University Press, Melbourne.

"LAND CONDITION" AS A SURROGATE FOR BIODIVERSITY HEALTH IN TROPICAL SAVANNA RANGELANDS

Alaric Fisher [1], Alex Kutt [2], Alan Andersen [3], Robert Karfs [1], Damian Milne [1] and Jenni Risler [1]

Tropical Savannas Management Cooperative Research Centre, and
[1] Department of Infrastructure, Planning and Environment, PO Box 496, Palmerston, NT 0810
[2] Environmental Protection Agency, PO Box 5391, Townsville, Qld 4810
[3] CSIRO Sustainable Ecosystems, PMB44 Winnellie, NT 0822

ABSTRACT

There are well-established procedures and indicators for assessing and monitoring "land condition" in Australian rangelands. None of the current monitoring programs explicitly encompasses biodiversity, although it has been suggested that some indicators of land condition may also be useful surrogates for biodiversity health. We tested this assumption through detailed biodiversity assessment at sites in a range of condition states in two pastoral regions in northern Australia, the Victoria River District (Northern Territory) and the Dalrymple Shire (Queensland). In each region, and amongst most major taxa (birds, mammals, reptiles, plants, ants), there was significant variation in biotic composition between sites in different condition classes. The relationship between species richness and condition varied between taxa, but in each major taxon we were able to identify species and functional groups that had increaser and decreaser responses to condition. To at least some extent, therefore, conventional land condition assessment in rangelands can also be informative about biodiversity health. However, we also note a number of potential limitations to this conclusion.

INTRODUCTION

There is increasing expectation that Australian rangelands will be managed, by landholders and management agencies, in an ecologically sustainable fashion (eg. Commonwealth of Australia 2003). This requires the capacity to monitor the status of biodiversity across the rangelands, in addition to the existing capacity to monitor "land condition". The latter term, although not necessarily precisely defined, is a widely-used one that captures the notions of minimising soil erosion, retaining vegetative cover and maintaining pasture composition in a desirable state, so as to ensure long-term sustainable production. There are well-established procedures for assessing and monitoring "land condition" in Australian rangelands, with each jurisdiction having institutionalised monitoring programs (NLWRA 2001, Whitehead *et al.* 2001). These rely on a variety of methods, including permanent photopoints, plot-based assessment of vegetation cover, composition and soil-surface condition, and the use of satellite imagery for condition assessment over large areas. Each method also has an associated set of "condition" indicators – for example, the frequency and/or cover of perennial grasses is an important indicator in tropical savanna rangelands.

The existing rangeland monitoring programs do not explicitly monitor biodiversity, although it is recognised that this is a desirable goal (NLWRA 2001). Given the complexity that the term 'biodiversity' encompasses, it will never be possible to directly assess more than a small number of components, and many indicators or surrogates for biodiversity have been suggested for use in rangeland monitoring (eg. Smyth *et al.* 2003). Suggested indicators include a number already used in land condition monitoring and Whitehead *et al.* (2001) considered that validation of these putative biodiversity indicators was a high priority for further research. In this paper we describe some preliminary results from a study in Australia's tropical savanna rangelands that explored the link between land condition and biodiversity. By detailed biodiversity assessment at sites in a range of land condition states, we explored what information about biodiversity status may be contained within the current indicators for assessing land condition. This should then help to determine what additional indicators are required for a robust rangeland biodiversity monitoring program.

METHODS

The study focused on two important pastoral regions in northern Australia – the Victoria River District (VRD; Ord-Victoria bioregion; 17°S 131°E; mean annual rainfall at VRD Stn 640 mm) in the Northern Territory and the Burdekin Rangelands (BR; Einasleigh Uplands bioregion; 19°S 145°E; mean annual rainfall at Greenvale 630 mm) in Queensland. We sampled two major land types in each region, representing a contrast between those that are considered relatively resilient (vertosols and ferrosols) or more sensitive (chromosols and kandosols) to the effects of pastoral use – although only results from the latter type are presented here. Both regions are used for extensive cattle grazing on predominantly native pastures, although there is a generally greater intensity of use in the BR, with smaller properties (100-500 sq km, vs 1000-5000 sq km in the VRD) and generally higher stocking rates (10-25 AE/sq km, vs 5-15).

We sampled 48 sites on two properties in the VRD, on red calcareous loams (kandosols) with Silver Box *Eucalyptus pruinosa* and Desert Bloodwood *Corymbia opaca* open woodlands having an understorey of *Sehima nervosa, Chrysopogon fallax, Heteropogon contortus, Dicanthium fecundum, Enneapogon* and *Aristida* spp. In the BR, we sampled 36 sites on three properties, on sedimentary chromosols with a mixture of Box (*E. persistens*) and Ironbark (*Eucalyptus* sp. [Stannary Hills G.W.Althofer 402]) woodlands having an understorey of *Bothriochloa* spp., *H. contortus, Themeda triandra, C. fallax, Aristida* and *Eragrostis* spp. Sites were stratified according to land condition but chosen to otherwise minimise environmental variation. In the VRD, selection of sites in different condition was based on regional land condition mapping produced by DIPE (derived from cover-change analysis of a time series of satellite imagery from the ten years preceding sampling; Karfs *et al.* 2000), supported by aerial and ground inspection. In the BR, site selection was guided by advice from QDPI extension officers and landholders, supported by ground inspection. Due to differences in property sizes, variation in site condition occurred across fencelines or along grazing gradients within properties in the VRD, but between adjacent properties with different management histories in the BR. For the purpose of this paper, we attribute all sites to three simple land condition classes ("poor", "intermediate", "good"), noting that these are relative terms. Compared to "good" sites, "poor" sites typically had low perennial grass cover and frequency, high cover of bare ground and high recent grazing pressure (Fig. 1).

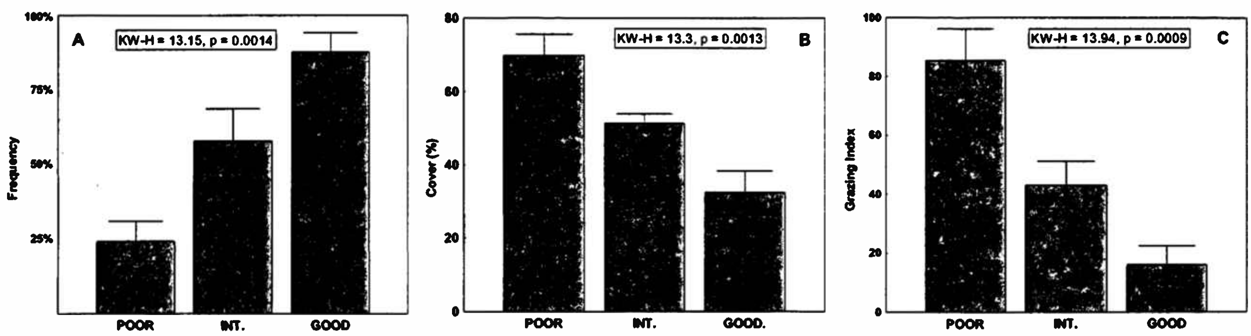


Figure 1. Example comparison of sites in the three condition classes at one of the VRD properties for (a) perennial grass frequency, (b) cover of bare ground, (c) index of recent cattle use. Bars are means, with one SE; Kruskal-Wallis statistic is given in the box.

Biodiversity sampling occurred at 1 ha (100x100m) sites, with groups of sites sampled over a four day period. Within this site, birds were censused during eight diurnal and two nocturnal five-minute visits. Other vertebrates were sampled using 24 Elliott box traps (baited with a mixture of oats, peanut butter, honey and tuna or dog biscuits), four 20 litre pit buckets each with 10 m of drift fence, and three diurnal and two nocturnal, 15-minute searches. Ants were collected using 70 mm diameter pit-traps in a 3 x 5 array, with 10 m between pits, open for 48 hours. Termites were also sampled at selected sites in the NT, although these data are not presented here. A complete floristic list for the site was collected, with cover and frequency of understorey species estimated using 20-25 0.5 sq m quadrats in a regular grid; these quadrats were also used to measure ground layer cover of vegetation, litter, rock and bare soil. Additional 'habitat' variables were measured at each site, relating to vegetation structure, substrate, recent grazing pressure and fire history.

In this paper we examine whether species composition differs between sites in the three different land condition classes, using ordination (multidimensional scaling, with Bray-Curtis similarity measure and square-root transformed abundance or frequency data) and ANOSIM analysis. We also explore difference between condition classes for species richness and relative abundance of various taxonomic and functional groups, and abundance of individual species, using Kruskal-Wallis tests.

RESULTS

Victoria River District (calcareous loams)

We recorded a total of 240 plant, 72 bird, 9 mammal, 20 reptile, 1 frog and 123 ant species from the 48 VRD sites. There was a pronounced difference in composition between sites from the two areas sampled, for all taxonomic and functional groups (Table 1, Fig. 2). There was also a significant difference between condition classes for composition of all groups other than bird guilds (Table 1), with the poorest separation between classes being for birds. Similar patterns were observed when comparison of condition classes was made separately for the two stations, although the dissimilarity between condition classes for most taxa was more pronounced at one property (VRD2 in Table 1).

Mean plant species richness was lower in "good" sites, which had relatively high richness of perennial grasses but lower richness of annual grasses and annual and perennial forbs (Fig. 3). Richness and abundance of ants was also lower in "good" sites, due particularly to high numbers of "Hot Climate Specialists" (*Melophorus, Meranoplus* and *Monomorium* spp.) in the poorer sites. Reptile richness and abundance was significantly lower in the "poor" sites, with higher numbers of Scincidae in the better sites contributing most to this effect. While there was no significant difference between condition classes in richness or total abundance of birds, there were trends in the relative abundance of bird foraging guilds, the most pronounced being the high abundance of granivores in "poor" sites.

Analysing the response to condition of individual species was hampered by the relative rarity of a high proportion of the flora and fauna. Nevertheless, a number of the more common species in each taxon showed obvious decreaser (more abundant in good sites) or increaser (more abundant in poor sites) response patterns (Fig. 4).

Table 1. Results of ANOSIM analyses testing whether species composition of various taxonomic and functional groups differed between condition classes for: all Burdekin Rangeland sites (BR cond); all Victoria River District sites (VRD cond); and sites at each VRD station (VRD1, VRD2 cond). The effect of location on composition was also tested for VRD sites (VRD loc). Numbers are the ANOSIM R statistic, with significance (^{ns},P>0.1; *,P<0.1; **,P<0.01; ***,P<0.001). Letters in brackets are results of pairwise comparisons showing which condition classes were significantly dissimilar (eg. GP, PI indicates "good" sites were different to both "intermediate" and "poor" sites, but the latter two were not dissimilar).

Group	BR cond	VRD loc	VRD cond	VRD1 cond	VRD2 cond
all plants	0.13* (GP, GI)	0.54***	0.19** (GP, GI)	0.13* (GP, GI)	0.25** (all)
ground layer plants	0.14* (GP, GI)	0.66***	0.20** (GP, GI)	0.14* (GP, GI)	0.25* (all)
ants	0.13* (GP, GI)	0.86***	0.20*** (all)	0.17** (PG)	0.23** (all)
ant functional group	0.07 ^{ns} (none)	0.14**	0.16** (GP, GI)	0.23** (GP, GI)	0.08* (GP, IP)
birds	0.02 ^{ns} (none)	0.56***	0.09* (GP)	0.11* (GP)	0.08* (GP)
bird guilds	0.03 ^{ns} (none)	0.14***	0.02 ^{ns} (GP)	0.06 ^{ns} (GP)	-0.02 ^{ns} (none)
mammals/reptiles	0.27*** (GP, GI)	0.28***	0.22** (GP, GI)	0.15 ^{ns} (GP)	0.25** (GP, GI)
all vertebrates	0.27** (GP,GI)	0.59***	0.14*** (GP)	0.09* (GP)	0.20** (GP)

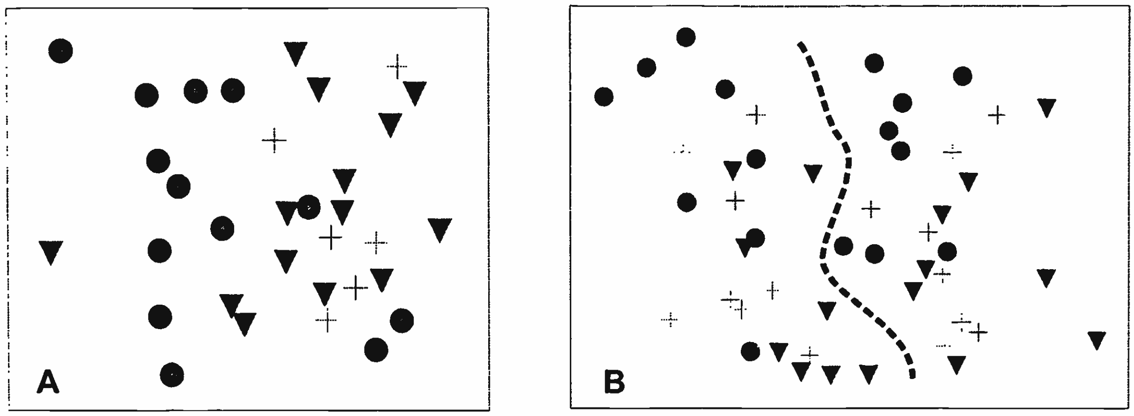


Figure 2. Ordination of sites by species composition for (a) mammals and reptiles at BR sites; (b) ants at VRD sites. Symbols indicate condition: circles, good; crosses, intermediate; triangles, poor. The dashed line on (b) separates sites at the two stations in the VRD.

Burdekin Rangelands (sedimentary soils)

We recorded a total of 210 plant, 70 bird, 12 mammal, 26 reptile, 3 frog and 104 ant species from the 33 BR sites. There was a significant difference between condition classes for composition of plants, ants, mammals and reptiles combined (Table 1), with the effect being most pronounced for the latter group (Fig. 2). In each case, pairwise comparisons showed no significant difference in composition between "intermediate" and "poor" sites, but significant difference between both of these and "good" sites. Bird composition did not differ significantly between condition classes but rather was strongly influenced by local variation in overstorey composition ("Box" vs "Ironbark" woodlands), and further analysis is required to tease out this confounding effect.

The mean richness or total abundance of many taxonomic and functional groups did not differ significantly between condition classes. However, the "good" sites had relatively low richness of plants, high richness and abundance of mammals, high richness of ants, and low abundance of birds (Fig. 3). The abundance of a number of the more frequent species in each taxon also showed pronounced 'increaser' or 'decreaser' responses to condition class. A small number of species were most abundant in the intermediate condition sites (Fig. 4).

DISCUSSION

These preliminary results provide evidence for substantial variation in biodiversity related to variation in land condition, within some tropical savanna land types. We have used only a crude delineation of condition, although we note that this mirrors the simple 'ABC' (or similar) condition assessment schemes presented in a number of Grazing Land Management manuals. Further analysis will examine the relationship between biodiversity variables and specific indicators, such as the frequency of perennial grass and various parameters provided by remote-sensed time-trend analysis.

The variation in composition between condition classes did not translate to a consistent relationship between land condition and species richness for all taxonomic groups. Interestingly, for plants and ants there was higher richness at sites in poorer condition, presumably because a high density of perennial grass excludes many other forbs and provides poor habitat for the many thermophilic ant species. This suggests that one goal of management should be to maintain habitat heterogeneity, rather than aim for a uniform sward of perennial grasses, even though this may appear to represent 'optimal' land condition. Conversely, the high species diversity in poor sites does not imply that entire landscapes in poor condition are desirable (from a biodiversity perspective), because such landscapes would lack many decreaser species.

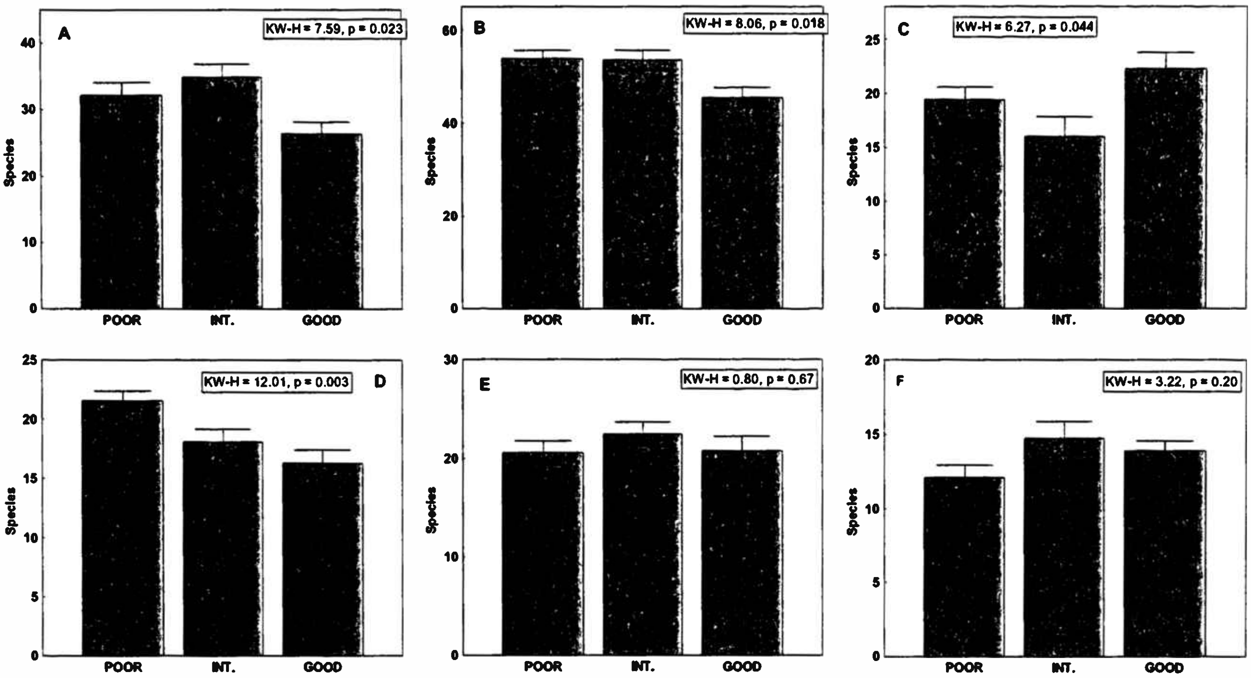


Figure 3. Mean species richness (with one SE) of sites in the three condition classes for (a) plants, BR; (b) plants, VRD; (c) ants, BR; (d) ants, VRD; (e) vertebrates, BR; (f) vertebrates, VRD.

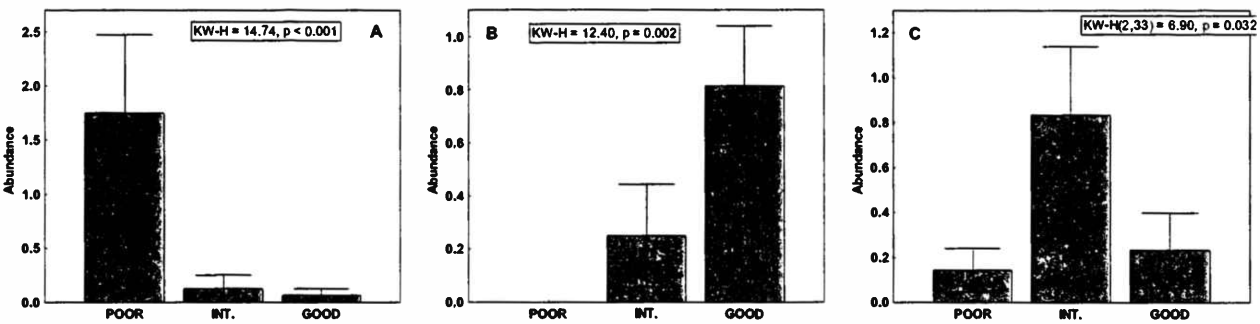


Figure 4. Examples of species' response patterns: (a) Crested Pigeon *Ocyphaps lophotes*, VRD (increaser); (b) Western Chestnut Mouse *Pseudomys nanus*, VRD (decreaser); (c) Robust Rainbow-skink *Carlia schmeltzii*, BR (intermediate).

The relative sensitivity of the various taxonomic and functional groups to differences in condition varied somewhat between sampling locations, although in all cases bird composition was least sensitive. This may reflect the scale of sampling, in that birds integrate variation in the landscape over broader areas than the other taxa considered here. Nonetheless, bird composition was sensitive to relatively minor habitat variation within the BR box/ironbark woodlands, and all taxa showed considerable compositional dissimilarity between the two VRD sample locations. While there were generally consistent responses to condition for species common to the BR and VRD, there is of course a high species turnover between such geographically distant regions. Therefore, to develop predictive relationships between land condition and biodiversity composition that can be widely generalised, we need to be able to confidently allocate taxa to response types, whether from empirical evidence or on the basis of ecological characteristics. This has been attempted for some taxa, such as the functional group classification for ants (eg. Andersen *et al.* 2004). In this study, closely related ants in different locations showed similar response patterns, while response patterns were also consistent between locations for other groups such as bird foraging guilds.

Some of the potential limitations on the use of land condition (as currently assessed) as a surrogate for biodiversity health in rangelands have also become clearer to us in the course of this study. It is likely that biodiversity responds in a complex fashion to both the spatial and temporal configuration of land condition across a landscape. The increasing use of remote sensing for condition assessment may help overcome the inability of plot-based assessment to provide spatial context, but we still have a very limited understanding of how spatial patterning of condition affects biodiversity at a landscape or regional scale. Equally poor is our knowledge of how biodiversity responds to changes in condition over time and whether regional improvement in condition is matched by similar improvement in biodiversity status. Another important issue is that condition monitoring concentrates on the more extensive pasture types in a region (as we have done in this study). However, rare and restricted ecosystems (eg. riparian zones) may have very high biodiversity significance, and the condition of the surrounding matrix may not adequately describe the condition, or biodiversity status, of these important zones. More generally, our restricted sampling was uninformative about the response of the rarest species to land condition. The lack of true reference sites (i.e. areas with minimal impact from pastoral use over the past century) also means that we cannot readily assess how close the current biotic composition in "good" condition sites is to what may be considered the 'intact' ideal. Finally, perceptions of condition may diverge between pastoral managers and ecologists. Kutt and Fisher (this volume) provide an example of areas dominated by introduced pasture grasses, which would be assessed by conventional monitoring techniques as being in "good" condition, whilst having poor biodiversity status. These limitations do not imply that land condition monitoring can tell us nothing about biodiversity status, but rather support the view that rangeland biodiversity monitoring programs must always incorporate a raft of indicators, operating at a variety of scales (Whitehead *et al.* 2001, Smyth *et al.* 2003).

ACKNOWLEDGEMENTS

We thank all the people who helped with fieldwork, processing specimens and data entry, including Martin Armstrong, Emily Bolitho, Kym Brennan, Justine Douglas, Tony Hertog, Jeanette Kemp, Donna Lewis, Kathy Nash, Jerome Petit, Irene Rainey, Charmaine Tynan and Martin Wegmann. John Woinarski and Jill Landsberg assisted with the development of the project. We are grateful to all the landholders who provided access to, and information about, their properties. This study was funded by Land and Water Australia and the Tropical Savannas CRC.

REFERENCES

Andersen, A.N., Fisher, A., Hoffmann, B.D., Read, J.L. and Richards, R. (2004). Use of terrestrial invertebrates for biodiversity monitoring in Australian rangelands, with particular reference to ants. *Austral Ecology* 29: 87-92.

Commonwealth of Australia (2003). *National Framework for Natural Resource Management Standards and Targets.* Natural Resource Management Ministerial Council, Canberra. http://www.deh.gov.au/nrm/monitoring/index.html

Karfs, R., Applegate, R., Fisher, R., Lynch, D., Mullin, D., Novelly, P., Peel, L., Richardson, K., Thomas, P. and Wallace, J. (2000). *Regional Land Condition and Trend Assessment in Tropical Savannas.* Implementation Project Report, National Land and Water Resources Audit, Canberra.

NLWRA (2001). *Rangelands – Tracking Changes. Australian Collaborative Rangeland Information System.* National Land and Water Resources Audit, Canberra.

Smyth, A., James, C. and Whiteman, G. (2003). *Biodiversity Monitoring in the Rangelands: A Way Forward. Vol 1.* Report to Environment Australia, CSIRO Sustainable Ecosystems, Alice Springs.

Whitehead, P., Woinarski, J.C.Z., Fisher, A., Fensham, R. and Beggs, K. (2001). *Developing an Analytical Framework for Monitoring Biodiversity in Australia's Rangelands.* Report to the National Land and Water Resources Audit, Tropical Savannas CRC, Darwin.

ANTS AS INDICATORS OF THE IMPACT OF PERENNIAL SHRUB LOSS IN CHENOPOD SHRUBLANDS OF SEMI-ARID SOUTHERN AUSTRALIA

S.G. Clarke [1,2], *J.M. Facelli* [2], *A.D. Austin* [1,2] *& A.N. Andersen* [3]

[1] Centre for Evolutionary Biology and Biodiversity, The University of Adelaide, SA 5005
[2] School of Earth & Environmental Sciences, The University of Adelaide, SA 5005
[3] CSIRO Tropical Ecosystems Research Centre, PMB 44, Winnellie, NT 0822

ABSTRACT

The impact of perennial shrub loss on ant communities was investigated in semi-arid chenopod shrublands of the Flinders Ranges, South Australia, in the context of the potential use of ants as bioindicators in land management. Clear differences in ant species assemblage were noted between areas with and without shrubs, most notably in the abundance of a dominant species of *Iridomymrex*. Ant species richness was shown to be positively correlated with the richness of ground hunting spiders and wasps. Ants appear to be sensitive to ecological changes associated with perennial shrub loss, and their responses correlated with those of other arthropod taxa. Ants therefore show promise as indicators of ecological change within this semi-arid habitat.

INTRODUCTION

Overgrazing within the chenopod shrublands of semi-arid southern Australia has resulted in the loss of native perennial vegetation and its replacement by exotic weeds across vast areas. Such vegetation change is likely to have a major impact on biodiversity and ecosystem function. Prior to 1971, the bluebush (*Maireana* spp.) shrublands in the Flinders Ranges National Park of South Australia had been degraded and fragmented by decades of heavy grazing by sheep. It has since continued to suffer high grazing pressure from goats, rabbits and kangaroos. Within this open shrubland, only relatively small patches remain with perennial shrubs as the dominant overstorey, while Wards weed (*Carrichtera annua*), an exotic annual herb, dominates the residual area. Neighbouring sheep stations have retained large tracts of shrubland, and have reduced Wards weed invasion through more conservative stocking rates.

Within these chenopod shrublands, ants are one of the most abundant and species-rich arthropod groups (Clarke *et al.* 2003). Despite being touted as the quintessential indicator of ecological change (Majer 1983, Andersen 1990), the evidence for the use of ants as bioindicators in arid environments is still in debate (Hoffmann and Andersen 2003, Andersen *et al.* 2004). Previous work on the response of ants to disturbance in semi-arid environments has concentrated on the impacts of mining (Read 1996, Hoffmann *et al.* 2000), fire (Hoffmann 2003) and grazing (Landsberg *et al.* 1999, Hoffmann 2000, Read and Andersen 2000), or active regeneration of native vegetation during minesite rehabilitation (Andersen 1997, Majer and Nichols 1998). We are not aware of any previous studies examining ant responses to passive habitat recovery following long-term disturbance. The extent to which ant responses reflect those of other arthropod groups is also unknown in semi-arid environments (Andersen *et al.* 2004).

In this study, patterns of ant community structure in relation to the occurrence of shrubs are described within the bluebush shrubland, and ant species richness is correlated with the richness of two other arthropod groups, ground hunting spiders and wasps. The project aims to provide a greater understanding of the usefulness of ants as bioindicators in arid environments, as a potential tool for land managers to monitor habitat recovery.

METHODS

Study sites

The study took place in the Flinders Ranges National Park and on the neighbouring sheep property Wirrealpa Station, in the northern agricultural district of South Australia. All study sites are located in the plains areas of the Flinders Ranges, and receive an erratic annual rainfall of approximately 300 mm. The main shrub species on these plains are *Maireana astrotricha* (low bluebush), *M. pyramidata* (black bluebush), and *Nitraria billardierei* (nitre-bush). The exotic annual Wards weed (*Carrichtera annua*) is extremely prevalent, and dominates areas devoid of perennial shrubs.

A total of nine sites were surveyed, including three paired shrub/no-shrub sites within the National Park. Within each pair, one site was chosen inside a patch of shrubland (SHRUB), dominated by *N. billardierei* (Site 1), *M. pyramidata* (Site 2), or *M. astrotricha* (Site 3), with the other site of the pair at least 150 m from the outside edge of the patch in ephemeral herbland dominated by Wards weed (NO SHRUB). Three additional (SHRUB) sites were chosen on neighbouring Wirrealpa station. These were separated by at least 1 km, and were all dominated by *M. astrotricha*. Shrub cover (approx. 10%) was similar on all SHRUB sites, although Site 1 had larger, more widely spaced *N. billardierei* shrubs.

Sampling

Two lines of five pitfall traps (70 mm diameter) were established at each site, with traps spaced by 10 m and lines separated by 25 m. Traps were installed with lids four weeks prior to sampling to avoid digging in effects (Greenslade 1973). Immediately prior to sampling, the lids were removed and 50 mL of 50% ethylene glycol and a few drops of detergent were added to each trap. Traps were opened for five days in December 2002. Once collected, samples were transferred to 70% ethanol and all arthropods were sorted to order. Ants, wasps and spiders were identified to morphospecies. Voucher specimens are currently housed in the Insect Evolution and Ecology Laboratory, Darling Building, The University of Adelaide, and will be deposited in the South Australian Museum. To describe habitat structure, three 3 m transects, each separated by 1 m were surveyed at each pitfall trap. Every 5 cm along each transect, the type and height of the highest structure (bare ground, litter, or plant species) was recorded.

Analysis

Multivariate analyses of ant species abundance data were performed using Non-metric Multidimensional Scaling (NMS) (Sorensen's Distance measure) in the PCOrd (Version 4.10) program. Multi-Response Permutation Procedures (MRPP), a non-parametric multivariate test for detecting significant differences between groups (McCune and Grace 2002) was used to test for the significance of the separation of the SHRUB and NO SHRUB sites. Regression analyses were performed on the average number of ant species and spider and wasp species for each site using the JMP (Version 4.0.3) statistical package.

RESULTS

Ant community

The ant species richness in the SHRUB sites was not consistently higher than in the NO SHRUB sites (Table 1). A degree of separation of the SHRUB and NO SHRUB sites can however be seen in the ordination of the ant assemblage (Figure 1). MRPP comparison of the ant assemblage data within the SHRUB and NO SHRUB sites revealed a significant difference (T = -31.26, A = 0.1489, p < 0.001) between the two groups. A small *Iridomyrmex* species (*Iridomyrmex* sp B. (*rufoniger* group)) explained a large amount of the variation along the axes. This species was collected in much higher numbers at two of the NO SHRUB sites, whereas it was either absent or collected in extremely low numbers at all other sites (Table 1). Only a few correlations of the ant community composition with the environmental variables were apparent ($r^2 \geq 0.2$) and these were: cover of bare ground, Wards weed and rock, and 0 cm structural category. No correlation with plant species or structural diversity was found.

Table 1. Ant species richness and abundance of *Iridomymrex* sp B (*rufoniger* group) at each site.

Site	Perennial shrubs	Ant species richness	*Iridomyrmex* sp B. abundance
National Park 1	SHRUBS	24	4
National Park 1	NO SHRUBS	18	3743
National Park 2	SHRUBS	16	0
National Park 2	NO SHRUBS	17	0
National Park 3	SHRUBS	17	1
National Park 3	NO SHRUBS	17	1542
Wirrealpa 1	SHRUBS	17	0
Wirrealpa 2	SHRUBS	21	0
Wirrealpa 3	SHRUBS	19	1

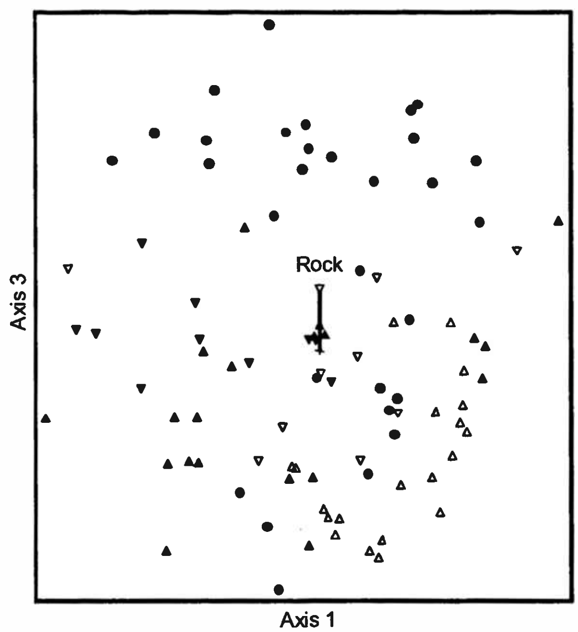


Figure 1. NMS Ordination of ant morphospecies assemblage (log χ +1). Open symbols are sites without perennial shrubs (NO SHRUB), triangles are sites within the National Park, and circles represent sites on Wirrealpa Station (SHRUB). (Stress 18.27, $R = 0.2$)

Regression analyses

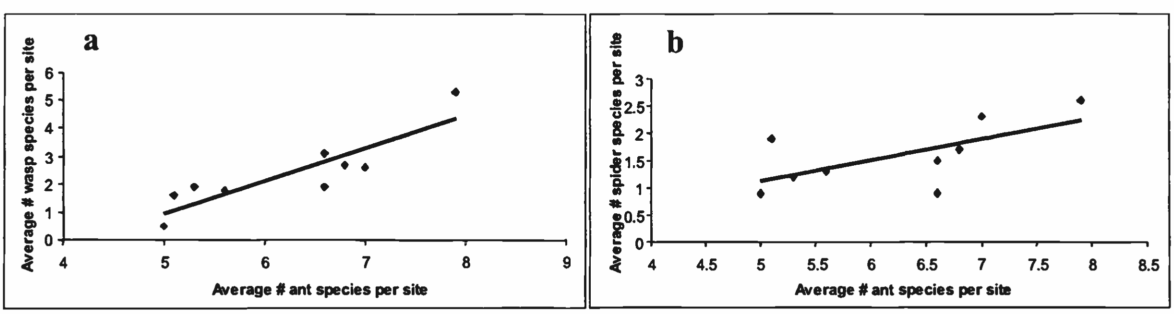


Figure 2. Regression analyses of number of ant species at each site (averaged over the 10 traps) against the average number of a) wasp species ($r^2 = 0.7657$, $p = 0.002$) and b) spider species ($r^2 = 0.4099$, $p = 0.0633$).

Results of regression analyses for average number of ant species against average wasp and spider species richness revealed positive relationships (Figure 2). Average number of spider species versus number of wasp species was also tested and revealed a positive but less significant relationship (r^2 = 0.5805, p=0.017).

DISCUSSION

Impact of perennial shrub loss on ant morphospecies assemblage

The loss of perennial shrubs has had no apparent effect on ant species richness, but appears to have altered species composition. This is a similar result to that found in the semi-arid tropics of northern Australia (Hoffmann 2000) and suggests that the removal of the perennial shrubland and its replacement with ephemeral herbland has affected the ant community.

The large numbers of *Iridomyrmex* sp. B collected at two of the NO SHRUB sites may be the result of the loss of shrub cover at these sites. This species appears to be numerically and behaviourally dominant where it occurs (*pers. obs.*) and is likely to affect the location of nests and foraging activities of many other ant species within its range. This could account for the changes in the ant assemblage noted between the SHRUB and NO SHRUB sites.

Several previous studies have found a correlation between plant species richness (e.g. Majer 1983) or structural diversity (e.g. Morris 2000) and arthropod diversity but this was not found in our study. This lack of correlation could be due to the low floristic and structural diversity in this environment when compared with habitats such as woodlands with understorey or grasslands. The *Iridomyrmrex* species present in the Flinders Ranges can also forage over large distances and have colonies of interconnecting nests (*pers. obs.*). The 3 m transects of the plant survey may therefore not have taken into account a large enough area for the important, widely foraging species, for which no relationships with the vegetation variables were revealed. However, the transects do appear to have been sufficient for most of the species with smaller home ranges for which some correlations were apparent.

The large numbers of *Iridomyrmex* sp. B at NO SHRUB Sites 1 and 3 was not recorded at Site 2 in the National Park. This site comprised a fairly small patch of ephemeral herbland near a large patch of shrubs, where the opposite was the case for sites 1 and 3. This provides more evidence, albeit circumstantial, that the plant characteristics of the wider area need to be taken into account when looking at ant assemblages in semi-arid environments, and may indicate a lower importance of small-scale structure and plant diversity for this species.

Correlations between ant, spider and wasp diversity

The positive correlation between the average species richness of ants and the average number of spider and wasp species is intriguing, however, an explanation for this effect is not obvious. The behaviourally dominant *Iridomyrmex* species and other carnivorous ant species may compete with ground hunting spiders sharing the same foraging space. Although a connection between ant and wasp assemblages is not so easily explained, most of the species collected were predators or parasitoids of ground dwelling invertebrates.

As a previous study (Majer 1983) found a similar phenomenon of ant species richness correlating positively with the diversity of other arthropod groups, this result deserves further consideration. The pitfall traps were not specifically designed to collect flying insects such as wasps, and these traps did not collect web-building spiders. Therefore other collecting techniques should be employed to investigate whether these correlations extend to wider samples of the wasp and spider assemblages.

Ants as bioindicators

Our results suggest that ants are responsive to the removal of perennial shrubs and their replacement with exotic ephemeral herbs within the Flinders Ranges. However, we could detect no simple relationship between ant species composition and plant species or structural diversity. In contrast, ant species diversity was closely correlated with the diversity of wasps and spiders.

This study highlights interesting possibilities for the use of ants as indicators of ecological change and arthropod diversity in chenopod shrublands. However, to be of practical use as a monitoring tool the results need to be easily measured, consistent, and repeatable. Ants are easily collected within this semi-arid environment using pitfall traps but the use of morphospecies for monitoring purposes is time consuming due to the taxonomic complexities of species level identifications. Ant species can, however, be placed into functional groups requiring identification only to genus. Indeed, an ordination of functional group data produced a better separation of SHRUB and NO SHRUB sites than that using species level data (Clarke *et al.* in prep). Therefore the use of functional groups should be considered for future monitoring work, despite their relative insensitivity to other land-use changes elsewhere in arid Australia (Hoffmann and Andersen 2003).

ACKNOWLEDGEMENTS

We thank Michael Woodcock, Jenny McInerney, Darrell and Pauline Clarke, and Ron and Sandra Bellchambers for field assistance, Warren and Barbara Fargher for access to sites on Wirrealpa station, and Chris Holden, Nicki De Preu, Peter Watkins, Matthew Kennnewell, and Arthur Coulthard from National Parks and Wildlife SA for logistical assistance. This work was funded by an Australian Postgraduate Award scholarship with supplementary funding provided by National Parks and Wildlife South Australia. Marta Kasper provided useful comments on a draft of the manuscript.

REFERENCES

Andersen, A. (1997). Ants as indicators of ecosystem restoration following mining: a functional group approach. *In* 'Conservation outside nature reserves'. (Eds P. Hale and D. Lamb). Centre for Conservation Biology, The University of Queensland, Brisbane pp. 319-25.

Andersen, A.N. (1990). The use of ant communities to evaluate change in Australian terrestrial ecosystems: a review and a recipe. *Proc. Ecol. Soc. Aust.* 16: 347-57.

Andersen, A.N., Fisher, A., Hoffman, B.D., Read, J.L. and Richards, R. (2004). Use of terrestrial invertebrates for biodiversity monitoring in Australian rangelands, with particular reference to ants. *Austral. Ecol.* 29: 87-92.

Clarke, S.G., Austin, A.D. and Facelli, J.M. (2003). Potential bioindicators of the impact of kangaroo grazing in native grassland in the Flinders Ranges, South Australia - order level arthropod diversity, ant species diversity and ant functional group composition. *Rec. S. Aust. Mus. Monogr. Ser.* 7: 93-100.

Greenslade, P.J.M. (1973). Sampling ants with pitfall traps: digging-in effects. *Insectes Soc.* 20: 343-53.

Hoffmann, B.D. (2000). Changes in ant species composition and community organisation along grazing gradients in semi-arid rangelands of the Northern Territory. *Rangel. J.* 22: 171-89.

Hoffmann, B.D. (2003). Responses of ant communities to experimental fire regimes on rangelands in the Victoria River District of the Northern Territory. *Austral. Ecol.* 28: 182-95.

Hoffmann, B.D. and Andersen, A.N. (2003). Responses of ants to disturbance in Australia, with particular reference to functional groups. *Austral. Ecol.* 28: 444-64.

Hoffmann, B.D., Griffiths, A.D. and Andersen, A.N. (2000). Responses of ant communities to dry sulfur deposition from mining emissions in semi-arid tropical Australia, with implications for the use of functional groups. *Austral. Ecol.* 25: 653-63.

Landsberg, J., Morton, S. and James, C. (1999). A comparison of the diversity and indicator potential of arthropods, vertebrates and plants in arid rangelands across Australia. *In* 'Transactions of the Royal Zoological Society of New South Wales'. (Eds W. Ponder and D. Lunney). The Royal Zoological Society of New South Wales, Mosman pp. 111-20.

Majer, J.D. (1983). Ants: bio-indicators of minesite rehabilitation, land-use, and land conservation. *Environ. Manag.* 7: 375-83.

Majer, J.D. and Nichols, O.G. (1998). Long-term recolonization patterns of ants in Western Australian rehabilitated bauxite mines with reference to their use as indicators of restoration success. *J. Appl. Ecol.* 35: 161-82.

McCune, B. and Grace, J.B. (2002). 'Analysis of ecological communities.' MjM Software Design, Gleneden Beach, Oregon.

Morris, M.G. (2000). The effects of structure and its dynamics on the ecology and conservation of arthropods in British grasslands. *Biol. Conserv.* 95: 129-42.

Read, J.L. (1996). Use of ants to monitor environmental impacts of salt spray from a mine in arid Australia. *Biodivers. Conserv.* 5: 1533-43.

Read, J.L. and Andersen, A.N. (2000). The value of ants as early warning indicators: responses to pulsed cattle grazing at an Australian arid zone locality. *J. Arid Environ.* 45: 231-51.

BIODIVERSITY MONITORING OR BIODIVERSITY MANAGEMENT SYSTEMS: WHICH IS THE CART AND WHICH IS THE HORSE?

H.J.R. Pringle [1] *and A.J.M. Hopkins* [2]

[1] Centre for the Management of Arid Environments, Department of Agriculture Western Australia and Curtin University, P.O. Box 417, Kalgoorlie, WA 6430. Hpringle@agric.wa.gov.au
[2] Department of Conservation and Land Management, Locked Bag 104, Bentley Delivery Centre Bentley WA 6983. angash@calm.wa.gov.au

ABSTRACT

The National Land and Water Resources Audit was initiated in order to assess the state of Australia's living natural resources, to better inform decision-makers, and to underpin further investment programmes to address the degradation of the country's living natural resources that has occurred since European settlement. For the rangelands, it was felt that an assessment was not feasible, and effort was focussed on developing an auditing framework. The Australian Collaborative Rangelands Information System (ACRIS) emerged as a result.

The major thrust of ACRIS involves consolidation of existing efforts across jurisdictions. However, ACRIS lacks information about biodiversity - apart from the information collected for pastoral resource monitoring, there is no regionally-consistent biodiversity monitoring over the *c* 75% of the continent referred to as the rangelands. Filling this identified gap is the focus of some of the work under ACRIS.

Present efforts to develop the biodiversity monitoring component of ACRIS have a strong research and science base. We suggest, as an alternative, an approach that is closely aligned with day-to-day management of the rangelands, and the use of Environmental Management Systems to guide that management. A nested hierarchy of EMSs from the regional through the catchment to the individual enterprise scale provides a suitable framework for achieving improved biodiversity management of the rangelands, including monitoring and reporting. We describe this framework and the approach being adopted in Western Australia to develop the regional-scale EMS components that provide the context for the operational-scale EMSs.

INTRODUCTION

The emergence of the conservation of biodiversity as a major issue and land management objective in the rangelands occurred at a time of paradigm shifting in the 1980s. This shift recognised the limitations of the maximum sustainable yield approach to the use of natural resources at the time of emergence of the concept of ecological sustainability (Anon. 1999, Morton *et al.* 1995, Pringle 1998).

Steve Morton and his colleagues broke through the initial confusion as to how biodiversity and maximum sustainable yield could be reconciled in rangelands with their landmark stewardship paper (Morton *et al.* 1995). CSIRO then undertook a series of major research projects to assess exactly how biodiversity's more easily measured components in more common habitat types were affected by the structure and history of pastoral development (James *et al.* 2000, Landsberg *et al.* 2002). They found that there are organisms that benefit, organisms that are adversely affected, organisms that show little response, and organisms that cannot persist in paddocks with artificial watering points and livestock. It is possible that the results were surprisingly positive: most species appeared capable of persisting in the paddocks sampled (Landsberg *et al.* 2002). However, it should be noted that the requirement for water remote areas in these paddocks made them unrepresentative of the rangelands as a whole; for example, by not including moist, drought buffering habitats amongst the water remote habitats. It is, therefore, almost certain that the findings were conservative (Pringle 2002) because important, less common habitats are invariably far more degraded (Pringle and Tinley 2003).

The National Land and Water Resources Audit (The Audit) identified that the rangelands' focus should be on developing the processes and information system such that, in future audits, the rangelands could be assessed with more rigour (Anon. 2001). The Audit may have inadvertently diverted attention from how to manage rangeland biodiversity, to how to monitor it, partly because there is a relatively small community of ecologists dealing with such rangelands issues.

MONITORING OR MANAGING BIODIVERSITY?

Steve Morton and his colleagues in Alice Springs gave us a path to explore that should have led to widespread improvement in the way that biodiversity was managed in the rangelands. And some of us took up the challenge of working out how stewardship could work locally and regionally with the rangelands communities and their representatives (Pringle *et al.* 2003). However, it seems that a preoccupation with reporting, for example, for national State of Environment reporting and for The Audit, diverted attention away from how to manage biodiversity better, to an elusive pursuit of a possibly never-to-be-funded rigorous national rangeland biodiversity monitoring programme. Similar experiences (from which we could learn) have already been had in the United States (Kepner and Fox 1991, West *et al.* 1994).

It would be wonderful to imagine that we could develop and then sustain a scientifically rigorous, national rangeland monitoring system that included biodiversity prominently (Anon. 2001, Watson and Novelly 2004). However, at this juncture, we lack the prerequisite visions, objectives, targets and key performance indicators that might justify a national rangelands biodiversity monitoring system being developed. We also lack the overarching management system into which the monitoring system would provide intelligence. We have failed to have the critical discussions of how to manage biodiversity in the rangelands, though some different approaches have been proposed (Fisher 2001, James *et al.* 2000, Pringle *et al.* 2003). And the people who manage most biodiversity are yet to be genuinely involved in most approaches.

The approach that we have attempted to develop in Western Australia involves directly the pastoralists who manage the *c* 980,000 sq km of pastoral leases, and managers of other land tenures in the rangelands. First, and in collaboration with a wide range of individuals, we have developed the basis for an enterprise-scale Environmental Management System for the rangelands. As a result of a pilot project in the Gascoyne-Murchison sub-region of the WA rangelands NRM region, there are now three pastoral enterprises in that sub-region (one cattle, one goat and one merino sheep) that have Environmental Management Systems and are internationally certified; all three have been re-audited recently (Taylor 2002). Each EMS is developed following completion of the Ecosystem Management Understanding (EMU) process, which identifies issues to be dealt with in the EMS and provides solutions (Pringle and Tinley 2001). The EMU-based EMS provides a sound model for the rangelands as a whole.

Second, we have developed a range of monitoring tools and protocols for use by pastoralists and other land managers that can inform management planning and decision-making. While these are mainly directed at specific management issues such as erosion and pastoral production, they provide a sound basis for engaging the pastoralists in monitoring a broader range of issues including particular biodiversity values and native vegetation condition as a general biodiversity indicator (www.emuproject.org).

A key issue that has arisen in developing the enterprise-scale EMSs is a lack of context. For example, how does one determine the biodiversity conservation outcomes to be included in each enterprise's EMS when there is no overarching, regional biodiversity conservation plan? If there was such a plan, with the [hypothetical] goal of "no further loss of biodiversity from the sub-region," it would be appropriate to include in the enterprise-scale EMS the protection and conservation of all populations of any rare and threatened species (as happens, but in a somewhat *ad hoc* manner).

In response to this emerging conundrum, we developed a conceptual planning framework for the rangelands involving a nested hierarchy of EMSs, as illustrated in Figure 1. The next challenge is to develop the higher level EMS in a manner that is inclusive yet produces useful and meaningful results that provide the context required at the enterprise scale. An initiative of the Rangelands Region NRM Coordinating Group which we describe below will inform assessments of regional priorities that will deliver the required context to enterprise-scale EMSs as well as the opportunity to develop similarly rigorous and accountable processes at a regional level (see below). A coherent, holistic and hierarchical framework for regional NRM is within our grasp for Western Australia's rangelands.

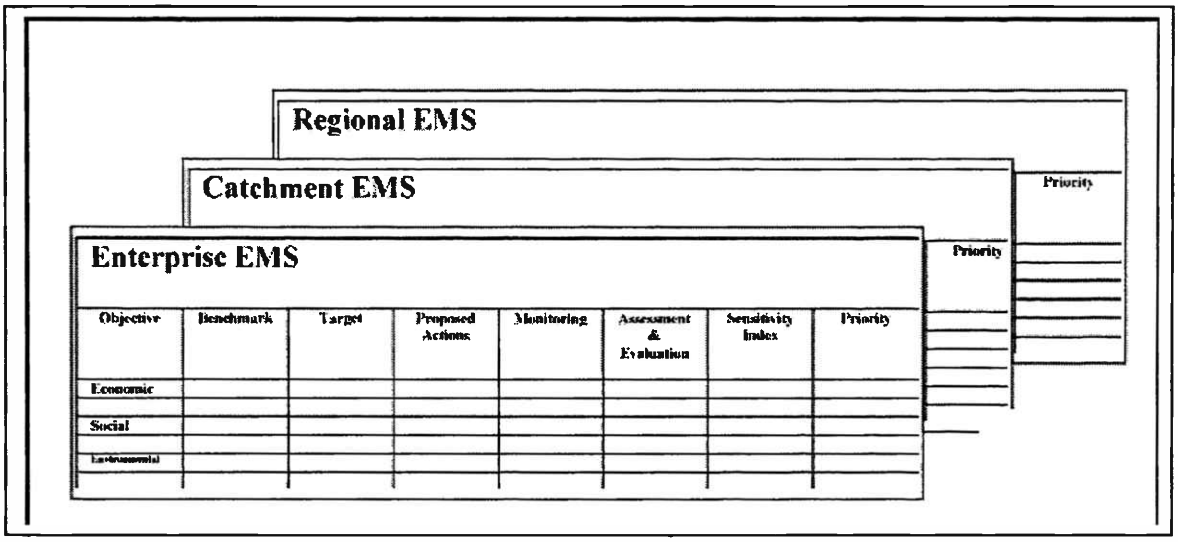


Figure 1. The nested hierarchy of EMS identified as the ideal model for planning and managing the rangelands.

THE EAGLE PROJECT: A PARTICIPATORY, VERTICALLY INTEGRATED AND INFORMAL EMS APPROACH

The Rangelands Region NRM Coordinating Group established to deliver investment funds under the Natural Heritage Trust II approached the EMU Team and asked if we could build some EMU principles and processes into the regional NRM planning initiatives currently underway. The hope was that we could develop some common ecological understanding of sub-regions with regional stakeholder representatives and support staff and provide a framework with which to develop integrated, rather than thematic and disintegrated priorities, management plans and investment strategies. This was timely, as we had been working conceptually on a participatory model for "paddock to parliament" Environmental Management Systems (Pringle *et al.* 2002, Pringle *et al.* 2003), and Angas Hopkins had recently been appointed co-ordinator for the State Biodiversity Strategy development project. Now we had some specific demand and resources to start on implementation. Our funding submission to do this work has been recommended by the W.A. Joint Steering Committee and we await an anticipated favourable outcome. The project will be underway at the time of the conference in Alice Springs in July and progress will be reported there.

The focus of the pilot project will be the Gascoyne-Murchison sub-region, but support will also be given to key NHT and State Government staff in the Goldfields-Nullarbor, Pilbara and Kimberley regions. They can either run with the project with some assistance from us, or will conduct their sub-regional planning in a way consistent with future adoption of the Eagle process.

The project has four major components:

1. Preparation, preliminary evaluation and planning.

Preliminary work will be undertaken by the EMU Project Team to develop locally relevant workshop materials, information products and to identify study sites for sub-regional familiarisation.

2. Sub-regional Workshops.
   Workshops' content will include:
   i) Landscape concepts and processes – and introduction (also introduction to the map data sets).
   ii) Overview videos and discussion of ecosystem pattern and process within each major geo-ecological unit in the sub-region. For instance, in the Gascoyne-Murchison sub-region we would address at least one major westward flowing river, one major salt lake / internal drainage catchment and one major coastal / marine area.
   iii) On-ground visits to sub-regional priority entities and issues, with discussion on each.
   iv) Integration / consolidation of understandings, discussion of ecosystem management and landscape ecology principles and approach, and what that means for the planning processes in each sub-region.

3. Training for sub-regional NRM human resources.
   For support staff in the Gascoyne-Murchison Sub-region, as well as key staff from other sub-regions (and any members of the Rangelands Group who are interested and available), we will hold a four to six day field course. It will include two days of assessment of regional data sets, remotely sensed images and so forth to provide background to fundamental information and processes for each sub-region.

4. Follow-up workshops for sub-regions.
   Workshop focus will include:
   i) Opportunities for integrated asset management, bringing together the different priority sub-regional assets identified by different stakeholder groups (two days), and
   ii) Integrated asset management planning – to include developing projects that provide the desired level of integration and linking to investment program (two to three days).

We hope to reveal the major synergies available from working on multiple assets together within integrated projects and in so doing, develop an ecosystem management capacity within sub-regions.

Just as participants in the EMU Process focus their resources and management on local and catchment assets and threats to them within an overarching ecological model and appreciation of wider context (including on private and government conservation lands), so too will key stakeholders within sub-regions, but at a much broader scale. This nested consistency of prioritising investment and activity cognisant of wider context will enable vertical cohesion for "paddock to parliament" management of natural resources, including biodiversity. Funding will be allocated to projects within sub-regions based on the extent to which they address a hierarchy of asset values (including abstract values such as land literacy). Investment may differ substantially between integrated projects addressing internationally and nationally important (and threatened) assets to those whose significance is primarily part of maintaining biodiverse and productive local ecosystems.

Importantly, the process will look beyond thematic silo projects (e.g. Bushcare, Landcare, Coastcare and Rivercare) that can be inefficient and often suffer from lack of wider context. For instance, and we use an eastern coast example so as not to compromise the ethical processes before the project has even started in W.A., imagine a coral reef system that is being smothered in sediment. In this project, we would recognise this not simply as a marine issue, but one of catchment management as well. Quite conceivably, the bulk of funding would be invested many hundreds of kilometres away from the precious, threatened and degrading asset in the form of catchment restoration and reticulation of watering points away from critical control points for catchment function (Pringle and Tinley 2003). Our monitoring would focus on adaptively ameliorating the causes of degradation as much as the responses of the assets.

Local management systems will acknowledge sub-regionally or even globally important local assets, while sub-regional management systems will be responsive to, and encourage positive outcomes at, local levels. Tenure boundaries will be seen as artefacts that need to be accommodated, rather than as the boundaries for natural resource management objectives and projects. It is hoped that the integrated, community-based natural resource management that has emerged through the EMU Process (Murchison Land Conservation District Committee and the Ecosystem Management Unit 2002), will now blossom at higher levels based on similar attention to ecological context and ethical engagement and empowerment.

Together, the Eagle and the EMU processes will provide consistency of approach from "paddock to parliament", based on the following critical features:

1. Ethical, participatory processes as the basis for progress,
2. Linking resources to priorities from paddock to parliament,
3. Monitoring in many ways and places for many different reasons, but always to provide intelligence for better management first, and for generating rigorous reports second, and
4. Vertical interchange of contextual and outcome information to stimulate better management and policy.

Biodiversity will be managed better, more systematically, and we will document this progress. Managing, including monitoring, will be our focus.

ACKNOWLEDGEMENTS

Thanks to Ian Watson, Ben Norton, Annabelle Bushell and P-J Waddell for reviews.

REFERENCE LIST

Anon. (1999). *National principles and guidelines for rangeland management.* Australian and New Zealand Environment and Conservation Council ANZECC and Agriculture and Resource Management Council of Australia and New Zealand ARMCANZ, Canberra.

Anon. (2001). *Rangelands - Tracking Changes. Australian Rangeland Collaborative Information System.* National Land and Water Resources Audit, Canberra.

Childs, J., Whitehead, P., Woinarski, J., Fisher, A., and Verhagan, C. (2001). *Developing an adaptive framework for monitoring biodiversity in rangelands.* A report for the National Land and Water Audit Rangelands Project Report. Tropical Savannas Co-operative Research Centre, Canberra.

Fisher, A. (2001). *Biogeography and conservation of Mitchell grasslands in northern Australia.* PhD Thesis, Northern Territory University, Darwin.

Freire, P. (1972). *Pedagogy of the Oppressed.* Pelican.

James, C.D., Stafford Smith, D.M., Landsberg, J., Fischer, A., Tynan, R., Maconochie, J., and Woinarski, J. (2000). Biograze - melding off-reserve conservation of native species with animal production in Australian Rangelands. *In* Nature Conservation 5: conservation in production environments, managing the matrix. pp. 290-300. Surrey Beatty and Sons Pty Ltd, Chipping Norton, NSW.

Kepner, W.G. and Fox, C.A. (1991). *Strategic Monitoring Plan: Arid Ecosystems.* U.S. Environmental Protection Agency, Las Vegas, Nevada.

Landsberg, J., James, C.D., Maconochie, J., Nicholls, A.O., Stol, J., and Tynan, R. (2002). Scale-related effects of grazing on native plant communities in an arid rangeland region of South Australia. *Journal of Applied Ecology* **39**, 427-444.

Morton, S.R., Stafford Smith, D.M., Friedel, M.H., Griffin, G.F., and Pickup, G. (1995). The stewardship of arid Australia: ecology and landscape management. *Journal of Environmental Management* **43**, 195-217.

Murchison Land Conservation District Committee and the Ecosystem Management Unit (2002). The *Murchison River Project: Pastoralists restoring health to the Murchison River catchment.* Shifting Camp, Proceedings of the 12th Biennial Australian Rangeland Society Conference, pp. 312-313.

Pringle, H. and Tinley, K. (2001). Ecological sustainability for pastoral management. *Journal of Agriculture* **42**, 30-35.

Pringle, H.J.R. (1998). Environmental Auditing Beyond 'Range Condition': A Western Australian Perspective. *Journal of Arid Land Studies* **7S**, 35-38.

Pringle, H.J.R. (2002). *Grazing impacts in rangelands: Assessment of two contrasting land types in arid Western Australia from different land management perspectives.* PhD Thesis, Australian National University, Canberra.

Pringle, H.J.R., Lewis, M., Hopkins, A.J.M., and Curry, P.J. (2002). *A preliminary sustainability framework for the Gascoyne-Murchison Region of Western Australia.* Shifting Camp, Proceedings of the 12th Biennial Australian Rangeland Society Conference. 336-337.

Pringle, H.J.R. and Tinley, K.L. (2003). Are we overlooking critical geomorphic determinants of landscape change in Australian rangelands? *Ecological Management and Restoration* **4**, 180-186.

Pringle, H.J.R., Tinley, K.L., Brandis, T., Hopkins, A.J.M., Lewis, M., and Taylor L. (2003). *The Gascoyne-Murchison Strategy: A people-centred approach to conservation in arid Australia.* Invited paper, Proceedings of the International Rangelands Congress 2003, Durban, South Africa.

Smyth, A., James, C., and Whiteman, G. (2003). *Biodiversity monitoring in the rangelands. A way forward. Volume 1.* Centre for Arid Zone Research, CSIRO Sustainable Ecosystems, Alice Springs.

Smyth, A.K. and James, C.D. (2004). Characteristics of Australia's rangelands and key design issues for monitoring biodiversity. *AustralEcology* **29**, 3-15.

Taylor, L.J. (2002). *Developing an Environmental Management System. A practical guide for pastoralists.* Department of Agriculture Western Australia for the Gascoyne-Murchison Strategy, Perth.

Tinley, K.L. and Pringle, H.J.R. (2002). *What is the EMU Exercise?.*Shifting Camp, Proceedings of the 12th Biennial Australian Rangeland Society Conference. 349-350.

Watson, I. and Novelly, P. (2004). Making the biodiversity monitoring system sustainable: Design issues for large-scale monitoring systems. *AustralEcology* **29**, 16-30.

West, N.E., McDaniel, K., Smith, E.L., Tueller, P.T., and Leonard, S. (1994). *Monitoring and Interpreting Ecological Integrity on Arid and Semi-Arid Lands of the Western United States.* New Mexico Range Improvement Taskforce, Las Crusces, New Mexico.

INTEGRATING HISTORICAL DATASETS TO PRIORITISE AREAS FOR BIODIVERSITY MONITORING?

Anita Smyth [1], Vanessa Chewings [1], Gary Bastin [1], Simon Ferrier [2], Glen Manion [2] and Bretan Clifford [3]

[1] CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs, NT 0871
[2] Department of Environment and Conservation, PO Box 402, Armidale, NSW 2350
[3] Department of Infrastructure, Planning and Environment, PO Box 2130, Alice Springs, NT 0871

ABSTRACT

We conducted a 'proof of concept' study to assess the feasibility of using historical survey and environmental datasets for prioritising areas for monitoring biodiversity. Our specific interest was to test the conventional wisdom that existing survey data on plants and animals, and environmental products from satellite imagery collected for different purposes could be readily used to identify areas in the landscape where monitoring of biodiversity was a priority. If this proved to be true, we believe that the commercial benefits would be substantial as the costs of data gathering would be less, the large investment already associated with obtaining these datasets would be value-added and the maps of priority produced from the study would help land managers to target areas for monitoring biodiversity. In the late 80s and early 90s, Parks and Wildlife Commission of the Northern Territory (PWCNT) and CSIRO invested in the Central Australian Ranges Geographical Information System (CARGIS). We used the comprehensive datasets from this study, and spatially coincident airborne and satellite remote-sensing products from other studies as our data sources for this case study. In this paper, we report the value of using historical datasets for prioritising areas by highlighting the benefits and deficiencies with this approach and suggest improvements.

INTRODUCTION

Government natural resource management (NRM) agencies are calling for environmental performance reporting on the condition of biodiversity and other natural resources in Australia's rangelands. Whilst land managers are becoming increasingly interested in taking up such initiatives, they remain hamstrung by the lack of policy frameworks and tools to accomplish it. As most of us know, monitoring biodiversity is not an easy task whether you are a biodiversity expert or land manager. First, available resources for biodiversity are driven by erratic climate conditions. Another difficulty is land use pressures are uneven across landscapes and without years of on-ground experience it can be difficult to know confidently where damage is likely to be irreversible. Finally, knowing what to measure (e.g. Faith 2003), how and where it should be done for practical outcomes are daunting challenges indeed.

Ideally, to identify where to monitor biodiversity, we need a comprehensive and detailed knowledge of the distribution of all entities of biodiversity (genes, populations, species, communities, ecosystems) occurring within a region (Ferrier 2002, Faith 2003). Although considerable investment has been put into bioregional surveys, it remains unrealistic to ever expect such complete knowledge. Instead the common practice is to use those entities for which we do have information as surrogates for biodiversity as a whole (e.g. species, assemblage of species or ecosystems). There are many different types of surrogates that could be used from individual species to complements of species, ecosystems and communities (see review by Faith 2003). There is also a diversity of modelling techniques for deriving these surrogates ranging from coarse-filter ones using environmental domain modelling to the more intermediate filters of ecosystem mapping and general dissimilarity modelling (GDM) to the fine-filter modelling of individual species / species assemblage-environment modelling (Ferrier 2002). More importantly, they rely on a reasonable amount of biophysical data. With the development of the National Land and Water Resources Audit, State and Territory bioregional surveys and environmental data products, an opportunity exists to explore how readily available datasets can be used to identify where best to monitor biodiversity. There are notable benefits in using existing datasets for this purpose such as value-adding NRM investments and reducing R&D costs. However, these datasets often differ in their quality of measurement and spatial resolution, which raises concern about their utility for underpinning biodiversity monitoring. Datasets may need to be broken into subsets to accomplish our purpose and this may then compromise results for statistical modelling. Knowing their value will increase and improve their use for NRM planning and influence future design of, and investment in, bioregional surveys.

We are presently completing a 'proof of concept' study to assess the feasibility of identifying priority areas for monitoring biodiversity. Historical biological survey data and environmental products derived from a digital elevation model, and airborne and satellite datasets for the central Australian ranges region are used to create maps of compositional dissimilarity (i.e. collective biodiversity) and landscape condition classes to prioritise areas for monitoring. We chose this region because of the large number of datasets generated for the Central Australian Ranges Geographical Information System (CARGIS) project undertaken by CSIRO and Parks and Wildlife Commission of the Northern Territory (now the Department of Infrastructure, Planning and Environment) during the late 1980s and early 1990s (http://www.cse.csiro.au). This study used an assemblage or individual species approach to map the predicted distributions and likelihood of occurrence of plant and animal species for specific localities at a fine scale (Griffin and Duguid 1997). We used the CARGIS datasets and also introduced new climate and satellite datasets to create the initial models and carry out prioritisation analyses.

In this paper, we report on the benefits and deficiencies of using historical biological and environmental data to create an initial set of models for mapping compositional dissimilarity and then suggest some improvements. We specifically do not discuss the modelling aspects as these will be covered in the client's report and in another manuscript.

STUDY AREA

The study area was the region of the digital elevation model (DEM) created in the previous CARGIS study (Fig. 1). This covers some 53,000 sq km in central Australia (extending from the Strangeways Range in the north, east along the Harts Range, south to the James Range and to the western extent of the MacDonnell Ranges). It has parts of five bioregions – Burt, MacDonnell Ranges, Simpson-Strzelecki Dunefields, Finke and Great Sandy Desert. The study area is referred to hereafter as the DEM. Mismatch in the spatial extent of some datasets meant that the DEM was subset into a smaller area called sub-DEM.

SPATIAL STATISTICAL MODELLING AND DATA REQUIREMENTS

We used the non-linear, multivariate general dissimilarity modelling technique for modelling compositional dissimilarity as the first step in identifying priority areas mainly because it uses compositional dissimilarity (or complementarity) of survey areas as a surrogate of biodiversity. This measure indicates a larger amount of diversity in species occurrence than species richness alone. It is the mix of two components of biodiversity – the difference in composition of species between different habitats/environments and the difference in composition of species between spatially isolated occurrences of the same habitats/environments in the landscape (Pressey *et al.* 1993). The GDM was developed by Ferrier and colleagues (2002) to predict the compositional dissimilarity of biodiversity as it changes in response to environmental gradients at pairs of survey sites in the landscape.

Another value of the GDM is that it gives reasonable models with relatively small amounts of biological survey data. This is an important consideration as most rangeland regions are data-poor with few and possibly biased samples both spatially and taxonomically of biodiversity. An exception to this is the central Australian ranges, which are data-rich having CARGIS and, more recently, other bioregional surveys. However, if we need to subset datasets to adjust for anomalies, and thereby decrease the number of survey sites for modelling, then we have an opportunity to examine the performance of the GDM to predict compositional dissimilarity.

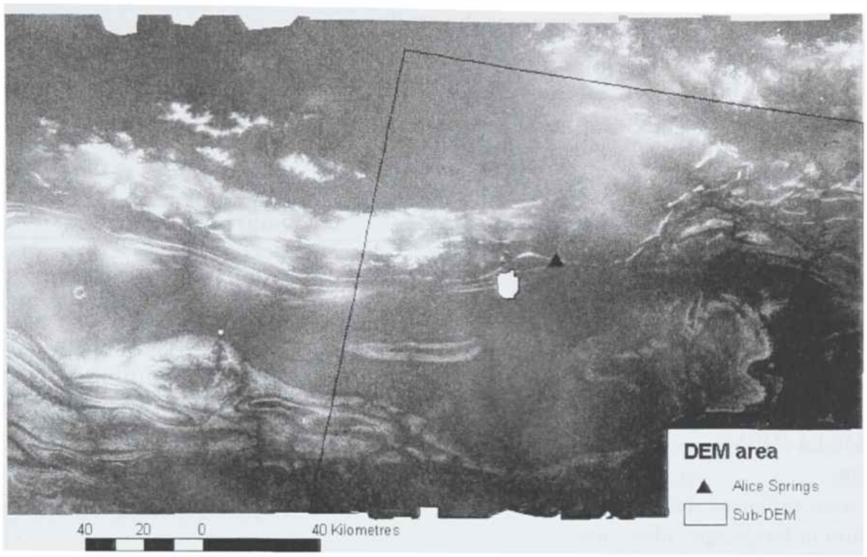


Figure 1. Map of the DEM (53,112 sq km) and sub-DEM regions (22,600 sq km) of the study area showing mountain ranges and plains. The distinctive ridges in the middle of the photo are the MacDonnell ranges.

The GDM requires spatial data on species occurrence and continuous data for environmental attributes. Our first step was to model predicted compositional dissimilarity and then extrapolate it for the entire study area, followed by a numerical classification of these predicted values in order to derive a map of differences in compositional dissimilarity across the entire study region. The next step will be to combine this information with a spatial index for landscape condition and use the environmental diversity approach of Faith and Walker (1996a,b), to prioritise and select areas for monitoring biodiversity.

READILY AVAILABLE DATASETS – GDM MODELLING

Two biological survey and sixty environmental datasets were used to conduct the GDM work. These are summarised in Table 1.

Biological Survey Data

The flora dataset contained information on the presence/absence of all perennial woody species for 4,683 sites. The data were collected from 248 transects which were 1 km long with up to 20 sites spaced 50 m apart. All species were recorded within a 20 m radius of the site. A GPS reading was taken for each transect at the first survey site and stepped out for the other 19 sites (G. Griffin, *pers. comm.*). To avoid a lack of independence of occurrence of plant species amongst sites, we used the single occurrence of species for the whole transect (25 ha) and assigned the GPS location recorded at the first site. This reduced the number of sites to 248 but the total area surveyed for all 20 m-radii was 62 sq km. No grasses or other non-woody, annual plants species were recorded. A total of 122 species were used to predict compositional dissimilarity for the study area.

The fauna dataset had presence/absence records from surveys of birds, mammals and reptiles for 117 sites throughout the DEM area. Only residents and non-irruptive species were used in the analysis. No invertebrate data was available for this study. The total number of species used for predicting compositional dissimilarity was 35, 110 and 76 species of mammals, birds and reptiles respectively.

These data were the response variables for the GDM modelling and were not aggregated into assemblages or taxonomic groups at this stage of the study.

Table 1. Description of datasets used in general dissimilarity modelling with spatial resolutions covering the Central Australian Geographical Information System (Griffin and Duguid 1997) and the digital elevation model (DEM) within CARGIS.

Layer	Source	Coverage
Flora records	Griffin (1997b,c)	CARGIS
Fauna records	Hobbs and Reid (1997a,b,c) Reid *et al.* (1997)	CARGIS
Geochemistry (iron oxide, calcium oxide, manganese oxide, magnesium oxide, silicon oxide, potassium oxide)	Griffin (1997a)	CARGIS
Digital Elevation Model (DEM)	Tier (1997)	DEM
DEM derived layers • slope, aspect, solar radiation, catchment size, wetness, position in landscape, elevation diversity, log catchment size, north-south slope.	Griffin and Chewings (1997) Tier and Chewings (1997)	DEM
Climate layers of temperature, radiation and moisture	ANUCLIM/BIOCLIM http://cres.anu.edu.au/outputs/anuclim.php	DEM
Satellite data • Landsat TM 1989 mosaic bands 1,2,3,4,5,7 • Probability of woody and non-woody vegetation cover derived from Landsat TM 1989 mosaic.	Furby (2002)	DEM
• PD54 (index of vegetation cover) variance and contrast (derived using Landsat ETM 2000 data)	Pickup *et al* (1993)	
Radiometrics – potassium, thorium, uranium, total count	Clifton (2003)	CARGIS

DEM Derived Layers

The resolution of the DEM was 100 x100 m pixels and all grid layers were calculated during the CARGIS study. Slope, north-south aspect, wetness, position in the landscape, elevation diversity, radiation and catchment size were the predictors for GDM modelling and are described in the references listed in Table 1.

Climate layers

Climate data for this study were derived using ANUCLIM 5.1 (http://cres.anu.edu.au/outputs/anuclim.php) and the radiation layers corrected for slope and aspect. We ran BIOCLIM (http://cres.anu.edu.au/outputs/anuclim.php) using both weekly and monthly calculations. Thirty-five predictors describing temperature, radiation, moisture and the seasonality of each were used in the GDM as predictors (see references for website listing of 35 variables).

Satellite data

Three types of satellite data were used to derive ten vegetation predictors: (1) Landsat 1989 TM raw bands 1, 2, 3, 4, 5 and 7; (2) derived images of the probability of woody and non-woody cover using the Australian Greenhouse Office (AGO) mosaic for 1989; and (3) textural measures of variance and contrast in vegetation cover calculated from the Year 2000 PD54 index. We used these predictors in an exploratory manner with incomplete knowledge of their possible relationships to the flora and fauna variables.

Radiometrics

A recent mosaic of radiometrics for the Northern Territory was provided by the Government Survey Office in the Department of Business, Industry and Resource Development (Clifton 2003). This was broken down into subsets and masked for the DEM area and five predictors were used: potassium, thorium, uranium, a total count of all three elements and a high-pass filtered total count.

GDM MODELS OF FLORISTIC AND FAUNAL DIVERSITY

Sixty-one predictors were used to model the floristic and faunal diversity as measured by compositional dissimilarity. Although we ran GDM models for weekly and monthly climate data, there was little difference in performance as measured by "explained deviance" and the following section reports modelling results for only the monthly climate data. A preliminary flora GDM with geochemistry as a surrogate for geology was run but this predictor was not selected as being influential. The most likely reason for this is that geochemistry measures rock and not soil chemistry and it is the latter which is more likely to influence plant diversity. We therefore did not use geochemistry in any additional GDM.

The performance of the historical datasets to model biodiversity varied noticeably between the sub-DEM and the DEM areas. For the DEM area, 31 of the 60 predictors best explained floristic diversity (Table 2) and the model was a reasonably good fit. The best model of faunal diversity used 18 predictors but it performed more poorly explaining just a third of the differences in animal diversity throughout the DEM area (Table 2). When we ran the same models for the sub-DEM, the best model for floristic diversity explained only 27% of the variation, a very poor fit. The fit of the fauna model was worse still with only 9% of the deviance explained (Table 2).

The most influential predictors of plant compositional dissimilarity in the DEM region were species turnover in different habitats (beta diversity), elevation, wetness, Landsat TM bands 1 and 7, total count of radiometric elements, slope, vegetation texture (variance index), seasonality of temperature, isothermality (mean diurnal range/annual temperature range), moisture of coldest quarter, moisture for lowest quarter, moisture for highest quarter and seasonality of moisture.

Table 2. Results of general dissimilarity modelling of flora and fauna compositional dissimilarity.

Model	Unexplained Deviance (%)	Null Deviance	Best Deviance	Number of Samples
Flora (DEM)	49.76	368.00	184.87	248
Fauna (DEM)	32.53	129.22	87.18	117
Flora (sub-DEM)	27.47	354.95	257.43	178
Fauna (sub-DEM)	9.24	344.89	313.02	40

PERFORMANCE OF HISTORICAL DATASETS

The performance of historical datasets is assessed using the fit of the GDM, their appropriateness relative to pre-processing effort and opportunities for improvement, and their ecological relevance.

Model fit

The historical datasets have performed surprisingly well at predicting plant diversity in the study area as a whole but not for the sub-DEM. Although the number of survey sites is smaller in the latter, the density of survey sites is similar (DEM – 0.005 and sub-DEM – 0.007 sites per sq km) and therefore this is unlikely to be the reason for the poor fit. A more plausible explanation is the location and smaller area of the sub-DEM (22,600 sq km). The DEM has proportionally more sites in the mountain ranges than the sub-DEM which has a balance of sites in lowland, slope and mountainous areas.

Given the small scale of the sub-DEM, it is likely that no gradients could be detected in the environmental predictors whereas they could be measured at the larger scale of the DEM (53,112 sq km). We believe that the sparse coverage of data points in the climate datasets, which represented just over half the predictors in the GDM, may have also contributed to the poor fit. A promised revision of the climate profiles in BIOCLIM for inland Australia may remedy this shortcoming (M. Hutchinson, *pers. comm.*). However, the fact that the landscape condition datasets were only available for the sub-DEM does present us with a challenge. We will either need to be more selective in our choice of climate predictors or develop a new approach for extrapolating the landscape condition datasets to the DEM in order to show how priority monitoring areas can be identified.

The performance of the historical datasets to model faunal diversity was very unsatisfactory. We interpret this poor fit to be caused by inappropriate and/or insufficient predictors of their habitat requirements. Climate, topography, radiation, the raw Landsat TM bands, radiometrics and the cover of woody and non-woody vegetation and its textural characteristics may describe broad patterns in potential habitat for animals (e.g. Coops and Catling 1997) but it's the temporal changes in the quality of that habitat over time that influence animal distributions at larger scales. Our historical datasets did not reflect temporal changes in environmental predictors. Even so, our results highlight that we need to explore further our choice of environmental predictors to understand exactly what aspects of habitats they represent especially the TM bands, radiometrics and the textural indices.

Pre-processing and improvements

Approximately 65 person-days were required for pre-processing the data. This included dataset selection, accuracy checks, projecting imagery from GDA94 to AGD66, conversion of categorical data to continuous data, derivation of new indices from existing datasets, creating climate layers, and masking datasets to the DEM and sub-DEM areas. Some anomalies existed that needed improvement, e.g. the vegetation field data were collected in transects up to 1 km in length, or 10 pixels of the environmental data. These transects often crossed gradients of slope and aspect, but we used the value of a single grid cell (the start of the transect) for each of the environment layers. This method of sampling will impact on the value of some layers more than others. The climate layers were generalised average surfaces and it is unlikely that they reflect conditions around the period of the ground sampling. Also, a DEM was essential for the derivation of climate layers and correction of radiation layers using slope and aspect made the products more convincing. The DEM was produced from streams, contours and spot heights in the early 1990s and took about a year's effort. A number of the field samples were also not used as they were located outside the DEM area. Ten years later, other available techniques could reduce the amount of resources needed to create a suitable DEM and it may therefore be possible to extend the area of the DEM at some stage.

We used available Landsat TM imagery from 1989 (around the time of the field work) and 2000 but the mosaics are composites of data acquired on various dates, so there are seasonal variations across the imagery, particularly in the wetter year of 2000. The layers showing probability of woody cover were derived using algorithms designed to map cover greater than 20% (Furby 2002), but much of the DEM area has sparse cover, possibly reducing the accuracy of this product.

A constraint of the modelling technique was the need for continuous data. This meant that we were unable to use some of the original CARGIS datasets (e.g. geology and land system mapping). We did explore using geochemistry (% oxides) as a surrogate but it was only available for some of the area.

Ecological relevance

The datasets used for the GDM were selected on what was available at the time. Ideally, we would have liked large amounts of continuous spatial data describing local climate, geology, soil and vegetation attributes that could be used to better describe the habitat requirements of rangeland biodiversity. Instead we have explored the possibility of radiometrics, raw Landsat TM bands, woody and non-woody vegetation and its derived textural characteristics as possible surrogates. We recognise that we were being exploratory and making a considerable leap of faith. Nevertheless, some of these were significant predictors and that allows further study of the implications of this for developing biodiversity indicators. For example, Landsat TM bands 1 and 7, total count of radiometric elements and vegetation texture (variance measure only) were some of the most significant predictors of the distribution of plant species occurrences. At this stage, we cannot explain why other TM bands, or their combinations, that indicate vegetation attributes did not feature. For example, TM 3 is a useful indicator of cover on predominantly red soils (Graetz *et al.* 1982), TM 2 and 3 are used to produce the PD54 index, TM 1 can indicate litter (Pickup *et al.* 2000) and TM 3 combined with one of the infrared bands (TM4-5, 7) indicates vegetation greenness (i.e. NDVI). Further ground-truthing studies are required to understand the ecological significance of the prominence of remotely-sensed layers in the GDM modelling and the distribution of plant species.

CONCLUSIONS

We believe that there are opportunities for using existing data to predict the patterns of biodiversity in the landscape at regional scales. Because we will never have information on the distributions of all plants and animals in the rangelands, there is an increasing demand by NRM and land managers to deliver practical indicators for monitoring biodiversity (see James, these proceedings). This means that we will need to model surrogates of environmental attributes to predict biodiversity patterns and know which environmental attributes consistently represent those patterns the best. Testing the efficacy of historical biological-survey datasets and environmental data is a critical first step. Having said this, we need to be cautious with their use and where possible, develop guidelines for their use in biodiversity modelling.

ACKNOWLEDGEMENTS

We gratefully thank Craig James and Andrew Ash for their helpful comments on the manuscript.

REFERENCES

Coops, N.C. and Catling, P.C. (1997). Predicting the complexity of habitat in forests from airborne videography for wildlife management. *International Journal of Remote Sensing* 18: 2677-2686.

Clifton, R. (2003): Radiometric Map of the Northern Territory 1:2,500,000. Northern Territory Geological Survey.

Faith, D.P. (2003). "Biodiversity", *The Stanford Encyclopaedia of Philosophy* (Summer 2003 Edition), Edward N. Zalta (ed.) http://plato.stanford.edu/entries/biodiversity/

Faith, D.P. and Walker, P.A. (1996a). Environmental diversity: on the best possible use of surrogate data for assessing the relative biodiversity of sets of areas. *Biodiversity and Conservation* 5: 399-415.

Faith, D.P. and Walker, P.A. (1996b). How do indicator groups provide information about the relative biodiversity of different sets of areas? On hotspots, complementarity and pattern-based approaches. *Biodiversity Letters* 3: 18-25.

Ferrier, S. (2002). Mapping spatial pattern in biodiversity for regional conservation planning: Where to from here? *Systematic Biology* 51: 331-363.

Ferrier, S., Drielsma, M., Mannon, G. and Watson, G. (2002). Extended statistical approaches to modelling spatial pattern in biodiversity in northeast New South Wales. II. Community-level modelling. *Biodiversity and Conservation* 11: 2309-2338.

Furby, S. (2002). *Landcover Change: Specification for Remote Sensing Analysis*. Technical report No. 9. National Carbon Accounting System. Australian Greenhouse Office.

Graetz, R.D. and Gentle, R.R. (1982). The relationships between reflectance in the Landsat wavebands and the composition of an Australian semi-arid shrub rangeland. *Photogrammetric Engineering and Remote Sensing* 48: 1721-1730.

Griffin, G.F. (1997a). *Geochemistry of rocks in the Central Australian Ranges.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

Griffin, G.F. (1997b). *Vegetation sampling in the Central Australian Ranges.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

Griffin, G.F. (1997c). *Plant species distribution in the Central Australian Ranges - Part 1: Introduction and methods.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

Griffin, G.F. and Chewings, V.H. (1997). *Solar radiation: Calculation and biological significance in the Central Australian Ranges.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

Griffin, G.F. and Duguid, A.W. (1997). *Central Australian Ranges ecosystems - Overview.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

Hobbs, T.J. and Reid, J.R.W. (1997a). *Bird fauna of the Central Australian Ranges - Species summaries and models.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

Hobbs, T.J. and Reid, J.R.W. (1997b). *Mammal fauna of the Central Australian Ranges - Species summaries and models.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

Hobbs, T.J. and Reid, J.R.W. (1997c). *Reptile fauna of the Central Australian Ranges - Species summaries and models.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

James, Craig, D. (this volume). Biodiversity monitoring in rangelands.

Pickup, G., Chewings, V.H. and Nelson, D.J. (1993). Estimating changes in vegetation cover over time in arid rangelands using Landsat MSS data. *Remote Sensing Environments* 43: 243-263.

Pressey, R.L., Humphries, C.J., Margules, C.R., Vane-Wright, R.I. and Williams, P.H. (1993). Beyond opportunism: key principles for systematic reserve selection. *Trends in Ecology and Evolution* 8: 124-128.

Reid, J.R.W., Hobbs, T.J., Morton, S.R. and Duguid, A.W. (1997). *Vertebrate fauna of the Central Australian Ranges.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

Tier, G. (1997). *Digital elevation model of the Central Australian Ranges.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

Tier, G. and Chewings, V.H. (1997). *Derivation of terrain layers from the digital elevation model of the Central Australian Ranges GIS.* Consultancy report to the Parks and Wildlife Commission of the Northern Territory. CSIRO, Alice Springs.

PRACTICAL BIODIVERSITY

Bob Purvis

Woodgreen Station, via Alice Springs NT 0870

I have a few minutes to put to you how we view biodiversity. Is it important or is it an airy-fairy scientist's dream? If you want sustainability then you must biodiversify.

We are constantly told that as pastoralists we must improve production, make more money, join the rat race, the motto being greed and growth. Well there are a few inhibiting factors to this that are ignored and should be taught to all school children. Australia is mostly a big desert with infertile soils, erratic rainfall, where water is precious, and that if you want more production, then there is a fair chance biodiversity will be a casualty to some extent.

Have you noticed that each progressive drought in Australia is considered to be the worst in history? Could it be that the land is over-utilised and is in worse condition as time goes on?

In our case, Woodgreen was taken up around 1920 and stock died in the 1928-30 drought. In the next drought, late 50's and early 60's, almost the whole herd died, and the best land was shockingly eroded. Since then, our aim has been to use the land but not degrade it. But how to measure our progress? It was obvious that there was a connection between the diversity of species of grass and the uses of that grass by cattle, horses, native grazers, birds, insects and so on. So I started to learn the plants and to observe what plants were required for the different animals to be in a healthy state. The next step was to try to adjust the number of animals so those better plants could maintain their health. And not be swayed by the fallacy that more stock means more money, but to touch the resource lightly and live within the constraints imposed by this.

The land on Woodgreen can be graded into three broad types. One, the majority, is where the soil is so infertile that it only grows mainly Acacias and Eremophilas (trees and shrubs) and Aristidas and Eragrostis (grasses), that are food for termites, which are food for lizards, which are food for some birds, with an odd kangaroo, but are of no use for domestic stock. The second type is country that cattle can use with year-round supplementation for breeding, and the third type is land fertile enough to fatten cattle on.

I came up with a simple test to determine the condition of that land. The test can be used anywhere on Woodgreen at any time with the possible exception of a long drought period. If the second-class country has more than seven species of edible grass or small perennial shrubs visible when standing in any one area, it is in good order. If it has five species it is at its lower limit, and if it has three species or less it is a degraded pasture. If the fattening land has ten species or above visible from the one spot, it is in good order. At seven species it is at its lower limit and three or less, it is degraded. My experience is that when both of these usable areas of land are in good order, then other living things are active and healthy.

There were too many kangaroos on Woodgreen and I wondered "why do we shoot and poison dingoes since they are natural predators of kangaroos". A kangaroo population is harder to control than a dingo population. And generally, dingoes will not harm strong cattle. So in the last forty years we have poisoned some dingoes only once, and shot an odd one when their packs number five or more. There are less rabbits now than in the mid 1950s because of the dingo. Domestic dogs gone wild we shoot at all times.

The NT Landrights Act may have been wonderful for lawyers but it was a disaster for the biodiversity of native animals on Woodgreen. A representative of ATSIC explained to me that Aboriginals have the right to kill to extinction. I don't believe this should be so. But in the bad time over ten years ago, they killed to local extinction on Woodgreen the echidna, turkey and emu, and almost removed the native bee, perentie and the euro. The perentie has regained his previous number, there are several turkey, two emus and a few colonies of native bee, but the echidna is gone. We regard Aboriginal hunting with motor car and rifle and white man's axe as being very destructive. Another disaster is the domestic cat gone wild.

Our records show that we can expect a drought of two years or more approximately every thirty years, and that you can expect two or more consecutive good seasons at roughly the same interval. When the consecutive good years come the pressure is on to run more stock, to make more money, to make up lost ground, to pay for new infrastructure etc. This should be resisted, for that is the time that there is sufficient build-up of litter to easily carry a fire. We are fools if we think that the land doesn't need to be burnt if we wish to be sustainably productive. The difficulty is to know how to achieve the least damage and the best result. If we don't burn then Woodgreen would become a wasteland of dense scrub. The things we have learned are this: frequent fires are a disaster and cool fires are a disaster, for they burn the grass and leave the scrub. Hot fires in general burn only some valuable trees. You may lose some trees with hollows, but fires also make new hollows to suit a range of nests, from pardalotes to major mitchells. The release of nutrients from a fire need not be short lived. The trick is not to use up all the new sweet growth, but to leave a considerable portion of it for the next litter bed for habitat and building of soils. The desirable frequency of fire may be every fifteen to fifty years.

On Woodgreen where there are areas of dense perennial grasses including buffel, growth of scrub is inhibited. We have over the years tried to introduce many species of grass to cover degraded areas but of those, only two varieties of buffel have been successful. Buffel is a real asset on areas where natives have been totally removed and as the condition of those areas improves, we have found that buffel is held in check by the return of native perennials. Dense stands of buffel are not desirable and detract from biodiversity.

We try always to keep a large proportion of the station in reserve and there are no sacrifice areas. Weeds are not a problem as there is always competition from desirable native species and no hay has been used by us for forty years. We use no chemicals and try not to interfere too much with the balance of nature but we also believe that you can run stock sustainably in central Australia.

On Woodgreen we have reduced cattle numbers to match the carrying capacity of the land. We have continued to make a living by continuously improving the quality of our cattle. I believe that biodiversity has benefited as the condition of the land has improved. But what about biodiversity on pastoral land more generally? Improving biodiversity is the responsibility of both land managers and the government. In closing, I would suggest that Lands departments and Land boards have almost always had their priorities slewed. The top priority now is how much can be earned from the land but the top priority should be the health of the land. Governments have paid lip service to this but I have not seen it seriously acted upon and this does not auger well for biodiversity.

MULTIPLE USE, MULTIPLE VALUES – GREATER THAN THE SUM OF THE PARTS

Kate Andrews

Knowledge and adoption manager, Land & Water Australia, GPO Box 2182, Canberra ACT 2601

ABSTRACT

Multiple use can be established at any geographic scale and over any time frame. The larger the area and longer the time period the greater the likely number of users and the greater the complexity of establishing and managing multiple use. This complexity is underpinned by multiple values. How do we negotiate with multiple users who seek different uses and may hold different values? How do we manage conflicting uses and values? How do we ensure that uses do not compromise each other or any values? This paper draws upon the experience of establishing the Lake Eyre Basin process to discuss these questions, and to ask yet more.

Fundamental to the idea of multiple use however is the belief that when we successfully bring together the different parts – users, uses and values – we can create a better whole that benefits us all; an outcome that we couldn't manage to achieve on our own.

WHAT IS MULTIPLE USE?

It has taken me too many cups of tea to figure out how to define multiple use for this paper. It is one of those terms that we use without often being challenged to unpack the assumptions that lie buried beneath. And after realising that tea wasn't going to help and moving on to something stronger I managed to develop my own map for multiple use rather than a single definition.

My own direct involvement with multiple use has been at a very large and general scale (the Lake Eyre Basin) however I have recently been lucky enough to see examples of people undertaking innovative multiple use at the farm scale.

A striking example is John Weatherstone who, with his family and over twenty years, has transformed their degraded sheep property into an enterprise with cattle, native seed orchards, a nursery, biodiversity planting and a demonstration farm for hordes of curious visitors. (For more information John has written his story which I've referenced below).

At the opposite end of the scale the Lake Eyre Basin process strived to bring together an enormous range of people and groups to understand the multiple values and uses in the Basin, and to create a way for people to manage the change and conflict arising from these diverse values and uses.

So multiple use can be undertaken, and is relevant, at almost any geographical scale, from the paddock to the catchment or region. And likewise it can occur over almost any time period. However the larger the area one works with and the longer the time period, the greater will be the number of users involved and the greater the complexity which will need to be managed. Different land tenures, legislative requirements, administrative boundaries, local cultures and the like, all make it a more daunting task. This was definitely the case for the Lake Eyre Basin.

In Figure 1 I've simplistically graphed this range or the scope within which examples of multiple use can be mapped. Most would, I think, fall somewhere in the box with the question mark.

The concept and practice of multiple use has taken a number of forms and generated conflict and debate in a number of fields. In particular I think of forestry and multiple use conservation reserves.

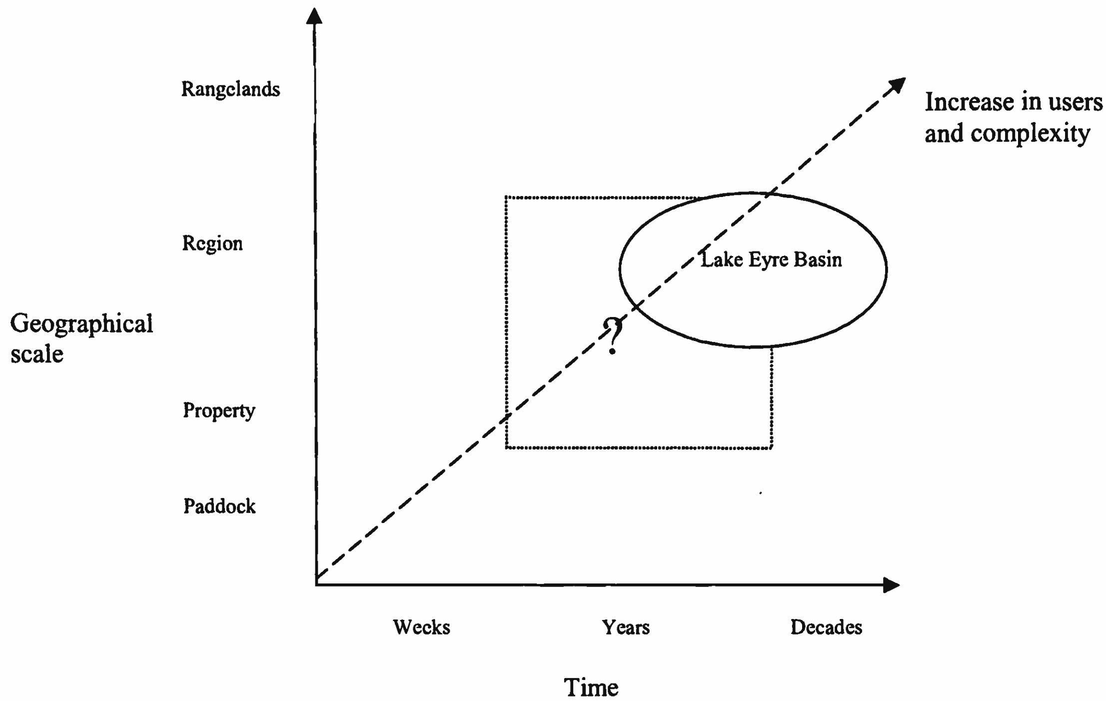


Figure 1. Scope of multiple use.

The forestry industry was an example where multiple use was interpreted as simply a way to maximise the economic benefit of an area of land or natural resources. What different uses and management practices can be undertaken to increase the productivity of an area? This definition is based upon holding a single value, the economic or productive value, for an area or resource. Even thirty years ago the forestry industry and their practice of multiple use, full utilisation and maximum yield was being criticised for focusing on only this one value. Kanowski (2003) writes about the Routleys work *The fight for the forests* which challenged this approach and presented an alternative approach for forestry in Australia based on respecting multiple values and delivering restrained sustainable yields.

There are numerous examples of multiple use to improve production capacity on one property or operation in agriculture (although it can be limited by the tenure type and lease conditions). The growth of tourism in the rangelands, and on pastoral properties, particularly around Alice Springs, the Flinders Ranges and central west Queensland is an obvious example. When local Aboriginal enterprises are linked, such as ecotourism ventures, the positive flow on effects for the whole local community become more substantial.

And sometimes economic benefit is not the main driver. I know some instances in the Lake Eyre Basin where land managers see tourism as an opportunity to educate urban Australians and to share with them some of the other values of the Outback. In these cases multiple use begins to be defined more broadly to incorporate values other than economic productivity.

In South Australia the practice of multiple use reserves was an attempt to achieve this. While seeking conservation outcomes, they allow for production outcomes through possible mining, oil, gas, or grazing activities (for example Innamincka Reserve). This could be considered a classic win-win, allowing for an increase in the area of conservation reserves in SA, while providing access for other activities, such as mining and grazing, with greater controls upon these activities. Conservationists have argued, however, that this mix of uses may compromise conservation outcomes and that resource use is not necessarily compatible with the protection of environmental values (Reeves 2000).

MULTIPLE VALUES?

So it seems that any discussion of multiple use brings us back to the fundamental of values. Most of us do value country for more than just its productive capacity. These other values influence the choices we make, the way we manage country, the lives we lead (although these other values can remain unacknowledged). We hold values personally, as a family, in our local community or as a society nationally and internationally. And these wider values influence our own values, or impact upon our own choices and actions, sometimes whether we like it or not. The proposed listing of Lake Eyre for World Heritage was a classic example of this. National and international communities are increasingly seeking to protect ecological and heritage values and these 'external' expectations are impacting upon local and regional communities. However they can also provide positive opportunities for communities and producers, for example the market for organic rangelands beef.

Through my work across the Lake Eyre Basin I experienced the economic, social, cultural and heritage, environmental, and spiritual values that people hold for this country. And I learnt never to make assumptions about what values people would hold or what values motivated them. I discovered that the hardest, crankiest old pastoralist might have a deep and powerful commitment to their country that I could only begin to understand.

A formal categorisation of values for natural areas includes:

- Commodity values – minerals, pasture.
- Amenity values – lifestyle, scenery.
- Environmental quality values – air, water quality.
- Ecological values – habitat conservation, biodiversity.
- Public use values – subsistence, recreation, tourism.
- Spiritual values (Stankey and Clark, 1991).

I would also include cultural and heritage values. These had, and have, an important role in the Lake Eyre Basin. The work undertaken for the Lake Eyre Basin Coordinating Group and the Australian Heritage Commission on Heritage Tourism, the *Inland Rivers – Outback Tracks* project captures the importance of this heritage to many Australians who now want access to it. Managing tourists' demands and expectations so they don't impact upon what draws them is a challenge this work will help people meet (see LEB website and Schmiechen 2004, referenced below).

Ecosystem services are a vital value that does not yet provide direct economic benefit to land managers. This more recently coined term equates to the environmental quality values in the list above. Studies have been done addressing how society could (and should) pay for the provision of services such as clean air and water. One example is stewardship payments to land managers.

NEGOTIATING MULTIPLE USE AND MULTIPLE VALUES

Given the complexity of dealing with multiple use and diverse values, how do we find our way to a positive outcome? I believe that it needs to be an inclusive process of negotiation, whether in a family, community or region.

The questions below pick out some of the issues that I believe need to be tackled when establishing or integrating multiple use, particularly at a larger scale.

The users

Who are the 'users' and who has an interest?

The values

What are peoples' values, needs and expectations?

Do we acknowledge and respect these even if we don't share them?

The outcomes and vision

What outcomes are we seeking?

Is there a vision we can share or can we develop a vision together?

The conflicts

Do any of the uses compromise any other existing uses or values? (Are any incompatible?)

Do they conflict with other needs or expectations?

Do they compromise possible future uses?

Existing knowledge and gaps

What information and knowledge do people have? (Local and scientific; economic, social and environmental.)

What other information is needed?

Do we have an informed understanding of how the possible or existing uses may affect or compromise other uses or values?

Are there ways to change practice to manage this and optimise all outcomes?

How do we ensure that we continue to learn from, and improve, what we are doing?

The negotiating process

What is an appropriate negotiation process for people which is relevant to their situation?

What are the guidelines and principles for this process?

Who is managing it? Is it more likely to be successful with an objective third party facilitating or mediating?

Although I have written the above questions as a sequence, of course reality is never that neat. When I write about the process we undertook in the Lake Eyre Basin it reminds me of the cartoon where an archer shoots an arrow at a tree and then paints a target around the arrow so that it is directly in the bullseye. Except in our case, the arrow didn't hit a tree but a scrub bull.

With regard to the first point above – the users – I think that sometimes the users or potential users may not be obvious. And some uses or users don't have as much weight as others for example if they aren't directly related to economic production. This can mean that they have less voice. Will it work if this is the case? Reinforcing the status quo is not always the best way, particularly if you've already decided that what the status quo is giving you isn't good enough or is creating conflict.

The second point concerning values can take a longer time to address. Being willing to let someone else speak is one thing but being willing to hear and respect their different values is a whole new step. And this can take more than talking. We found that travelling to different parts of the Basin and experiencing someone else's part of the country helped us understand them, and the country, better.

Sharing outcomes and a vision – why would you bother otherwise? Not only do you need to have an idea of what you are seeking but that you share it. I find it remarkable how such diverse people can share a vision. A friend from a town in north Queensland has been working to bring together her Aboriginal community with the cane growers and local businesses to create viable options for their area that provide for them all. The enthusiasm that is being generated by working across these groups is creating a wide range of new ideas and may also result in a land use agreement.

A clear example of point four is a conflict over use that arose in the Lake Eyre Basin, the Currareva proposal to establish cotton on the Cooper. An unusual alliance was formed when people realised that a number of values could be at risk. The extraction of water from the Cooper may have harmed the water supply of the local town (Windorah), the livelihood of pastoralists relying upon floodplain grazing, and the health of the river system and the biodiversity it supported. Less explicit was the perceived threat to cultural values. When a 'demonstration' was held in Windorah, a parade on horseback down the main street, people were also representing the importance of the outback culture and the pastoral industry to them. The incursion of intensive, high capital farming was seen as a possible threat to this way of life and culture. The 'battle over the Cooper' was a conflict over the introduction of a new land use that was seen to compromise existing uses and values. It also became apparent how little understanding we had about the possible impacts and the river system itself.

This lack of certainty is often a given in natural resource management. We can, however, ensure that we have based decisions upon the best available knowledge and are starting to address the knowledge gaps that we are aware of. In the instance above, further research was initiated that should help us better understand the relationship between use, impact and values in the Cooper catchment. We are also seeing more instances now where local and indigenous knowledge is being used alongside scientific knowledge. This acknowledgement of the value and usefulness of different forms of knowledge, and their integration, should help lead to better-informed decisions and more successful outcomes. Likewise we see the increased use and integration of economic, social and environmental information. How can we manage multiple use and values without an understanding of each of these (the triple bottom line) and how they may be impacted?

Once multiple use has been established there is always a need for ongoing learning and response to those lessons – adaptive learning and management. Monitoring of outcomes and impacts is an important way of ensuring that the uses do not impact upon each other or upon recognised values: economic; biophysical and environmental; cultural, social and heritage.

The final questions above in point six relate to the process of negotiation itself. Fundamental to the long-term success of any negotiation are open communication and the establishment of trust. Participation of all the parties helps create ownership of decisions and more likelihood of success.

THE WHOLE IS GREATER!

One of the original drivers for the individuals who bravely and optimistically kick started the Lake Eyre Basin process was to move forward from a position of antagonism and distrust between stakeholders, generated by the proposed World Heritage listing, to a position of greater understanding and perhaps mutual benefit.

One of my favourite quotes on negotiation states that negotiation "…is about breaking the paradigm of winning and losing and transforming negotiation into a search for improved solutions to problems." (pviii, Hall 1993). With this statement, Hall moves negotiation on from the traditional ball crunching variety of the 70s (bottom lines and ambit claims) to the process that we need to have to manage the complexity of multiple use and values in the rangelands for the benefit of us all, including the environment. The Lake Eyre Basin was one attempt at this, which still had a way to go. For those of us involved it did teach us that the whole is greater than the sum of the parts.

REFERENCES

Andrews, K. (2003). Pelicans, pubs and politics: negotiating a future in the Lake Eyre Basin. *Proceedings for the International Biennale on Negotiation*, Negocia, Paris.

Hall, Lavinia (ed) (1993). *Negotiation strategies for mutual gain – The basic seminar of the Harvard program on negotiation.* Sage Publications.

Kanowski, P. (2003). *Multiple values, partial use and restrained yield: where to from here for Australian forestry, 30 years on?*

Lake Eyre Basin Coordinating Group – website - www.lakeeyrebasin.org.au

Reeves, M. (2000). *Multiple use in national parks: Thin end of the wedge or pragmatic opportunism?* Community Biodiversity Network Website.

Schmiechen, J. (2004). *Heritage Tourism in the Lake Eyre Basin – future directions.* LEBCG (in press).

Stankey, G. and Clark, R. (1991). *Social aspects of new prescriptions in forestry: a problem analysis.* Grey Towers Press, Milford.

Weatherstone, J. (2003). *Lyndfield Park – Looking back, moving forward.* Greening Australia and Land & Water Australia, ACT.

ACACIA PEUCE: A CASE STUDY IN CO-OPERATIVE MANAGEMENT

R. Bloomfield [1], *J. Bloomfield* [1], *A. Markham* [2], *M. Heywood* [2] *and A.E. Bowland* [2]

[1] Andado Station, PMB 165, Alice Springs NT 0871
[2] Parks and Wildlife Service, PO Box 2130, Alice Springs NT 0871

ABSTRACT

This paper discusses co-operative efforts between Andado pastoralists and the Parks & Wildlife Service of the Northern Territory to fence and protect *Acacia peuce* (Waddy-wood), a relict species of desert tree classified as endangered (IUCN 2001). Issues, problems, and most importantly, the solutions are examined during this process for both the pastoralists and PWSNT. This case study may serve as a guide for similar projects in the future.

INTRODUCTION

Acacia peuce occurs in only three locations in Australia. The smallest population of *A. peuce* is located 230 km south of Alice Springs in the gibber country on the north-western edge of the Simpson Desert. Approximately 1200 *A. peuce* trees (43% of the population) are protected within fenced areas on the Mac Clark Conservation Reserve (MCCR), which was established by the former manager of the Andado Pastoral Station, Mac Clark, and managed by the Parks and Wildlife Service of the Northern Territory (PWSNT). A slightly greater number of trees are located on unfenced areas both within MCCR and on the surrounding Andado station. The *Management Program for Waddy-Wood (Acacia peuce)* prepared by the Parks and Wildlife Service, identifies unfenced *A. peuce* as being vulnerable to the activities of large domestic and feral animals. North Bore and its cattle yards, established many years ago in close proximity to the main stands of *A. peuce*, is a major focus of cattle activity in the area.

In early 2003, the Bloomfield family and the Parks and Wildlife Service commenced a co-operative effort to fence the unprotected *A. peuce* trees both within the Reserve and on Andado station. From the pastoralists' perspective, little economic benefit was to be derived from protecting this species without significant assistance from government agencies; the project involved the erection of 39 km of fencing, the relocation of two bores and attendant yards and equipment. For PWSNT, fencing the unprotected stands of *A. peuce* was seen as necessary to protect the genetic diversity of the species, to ensure that both mature and immature trees were protected from large herbivores, and to address the steady decline of outlying population fragments.

ANDADO STATION

Andado was established as a pastoral station in 1924. In the early years shepherding of sheep proved non-viable and since then the operation has focussed solely on beef production. The first bore, North Bore, located on the gibber flats in the major stand of *Acacia peuce* was drilled in the 1920s using a steam-driven drilling rig. The *Acacia* trees offered a good source of fuel for the drilling rig.

Mac Clarke, who occupied Andado from the early 1950s until 1985, realised the importance of the trees and allowed 3040 ha to be excised from the pastoral property and proclaimed as a conservation area by the NT Government. An unwritten agreement was that only major stands of trees could be fenced due to accessibility problems should the Reserve be fenced along its boundary. The Bloomfield family bought Andado in 1985 and Robert Bloomfield has managed it since 1993.

North Bore is the main handling and trucking yard for several surrounding waters. The location of the bore and inadequate fencing have resulted in negative impacts on the *Acacia* trees.

MAC CLARK *ACACIA PEUCE* CONSERVATION RESERVE (MCCR)

MCCR covers an area of 3042 ha and was excised from the surrounding pastoral station, Andado, in 1977 (Anon 1991). With only 475 ha fenced from large herbivores (camels, donkeys, horses and cattle), it offers protection to only 43% of the local *A. peuce* population. PWSNT rangers visit MCCR four to five times a year to carry out routine maintenance and to collect monitoring data on *A. peuce* and other wildlife.

Climatic data, collected at New Crown Station (25° 41'S, 134° 50'E), 90 km southwest of MCCR, were used to reflect the long-term rainfall trends and aridity of the area – indicating the harsh conditions under which the trees live. These showed that rainfall is low (annual mean is 188.3 mm) and variable, with 67% falling from October to March (data from Bureau of Meteorology). Water courses, usually dry, drain storm water run-off from surrounding high areas through MCCR. Seasonal temperatures are extreme: summers are hot (mean daily maximum for December, January and February at Finke Post Office 110 km southwest is 36.7^0 C with 25 days > 40^0 C; Bureau of Meteorology) and night temperatures in winter reach zero and below (mean minimum daily temperature for June, July, and August at Finke Post Office is 6.5^0 C with 13.4 days < 2^0 C; Bureau of Meteorology). Humidity is low and evaporation high. Strong south-easterly winds prevail year round (Deveson 1980).

MCCR occurs in the Andado site of botanical significance (White *et al.* 2000) which supports many disjunctions of plant taxa with arido-temperate and arido-tropical distributions. It is an important site for the conservation of several species at or near the edge of their continental range. The tree layer in the vegetation community is represented by *A. peuce* only, the shrub layer is represented by about 60% of the species and the grass sward by the rest (Deveson 1980). *A. peuce* generally grows on low sandy rises adjoining 'gibber downs' and drainage lines. The substrate is fragile and highly erodible as evidenced by gully erosion resulting from cattle and vehicle activity (Chuk 1982).

ACACIA PEUCE BIOLOGY

A. peuce flowers in the summer months between October and March. Immature pods may be present in very low numbers at any time of the year but the main season is between October and June, with a peak from December to May or June. Mature pods occur all year round, with low to moderate numbers present in any month except June.

Recruitment is infrequent; only one event (1978-1981) has been recorded in the last 50 years. Monitoring of seedling recruitment and establishment by PWSNT commenced early in the four-year germination event. Seedling numbers recorded in 12 plots (all but one in the fenced area) increased from 75 in 1979 to 154 in 1981. After 1981 few new seedlings appeared and there was a modest attrition rate. No mortalities of young trees were recorded between 1993 and 1999.

Growth rates are very slow and the trees are long-lived. The mean growth rate of ten tagged saplings over the period 1980 to 2002 inclusive, was calculated as 13.24 (±1.4) cm per year. As saplings gained height they grew faster (r = 0.8362). In mature trees the mean annual increment in circumference was calculated as 3.43 (±0.3) mm per annum which means that many trees live 500 years or more.

Any decline in the *A. peuce* population would likely result in significant losses in biodiversity; it is a keystone species in the local ecosystem and a prominent species in the Andado site of botanical significance (White *et al.* 2000). The shade of *A. peuce* is essential for water and energy conservation of several animal and plant species and the tree also provides food and shelter for many desert animals. At least 13 rare and threatened plant species are known to occur in this area. Letter-winged kites *Elanus scriptus* roost, nest and breed in the trees; the endangered plains rat *Pseudomys australis* plagues here during good seasons.

MANAGEMENT ISSUES

A number of management issues existed for both the pastoral operation and the conservation effort:

For Andado station:

- The operation needs to be economically viable to allow environmental issues to be addressed.
- Stockyards needed upgrading but the manager was unwilling to invest resources in case PWSNT decided to fence the Reserve along the proclaimed boundary. This would impede cattle management operations.
- Cost of re-drilling East Bore, relocating North Bore and attendant equipment was beyond the operational budget.
- There was no economic incentive to fence small, dispersed stands of the trees (39 km of fencing required).
- Presence of unprotected trees on Andado impacts on sound decision making.

For MCCR:

- The characteristic of germination and seedling establishment relying on abundant and prolonged rainfall, which is erratic and infrequent in current arid zone environments, may contribute to its demise in the long-term.
- Activities of feral herbivores (horses, camels, rabbits) and cattle have been identified as potential threats. Bowland and Heywood (2002) concluded that cattle could hinder all stages of the *A. peuce* life cycle (Table.1). Measures need to be taken to exclude large herbivores, in particular cattle, from all stands of *A. peuce*, both inside and outside the proclaimed area.
- As prominent sentinels of the flat gibber plains in the area, mature *A. peuce* trees are frequently struck by lightning. There is evidence that many trees have been struck and, significantly, not all survive. Lightning is an important mortality factor confronting the mature trees of this population of *A. peuce*; this process needs to be better understood.
- Apart from the direct impact on mature trees, lightning is a prime cause of wildfire when sufficient fuel-loads are present. Along with constraints of infrequent recruitment and severe habitat fragmentation, lightning may be a prominent factor in the possible extinction process.
- In plants, the negative effects of fragmentation in small, isolated fragments include reduced pollination, low seed production and recruitment, and increased inbreeding depression (Lennartsson 2002). The Andado population, dispersed over an area of about 300 sq km, is

Table 1. Summary of the impact of cattle activity on various stages of *A. peuce* life cycle (Bowland and Heywood 2002).

Impact	Germination and emergents	Seedlings	Saplings	Intermediate Trees	Mature Trees
Direct:					
Trampling	•	•	•		
Browsing	•	•	•	•	
Rutting			•	•	
Rubbing				•	•
Root exposure			•	•	•
Indirect:					
Herb layer removed	•	•			
Soil loss	•	•	•	•	•
Seed bank exposure	•				
Concentration of waste products	•	•	•	•	•

broken up into several fragments. The three smallest fragments, comprising two, three, and twelve individuals respectively, and large sections of the other fragments are not fenced and are vulnerable to the activities of large herbivores (Bowland and Heywood 2002).

CO-OPERATIVE MANAGEMENT PLAN

Two primary management actions for the conservation of the trees needed to be undertaken. The first was to relocate North Bore and its attendant cattle management infrastructure and redrill East Bore. Second, fence all stands of *A. peuce* on and off the proclaimed conservation area. The details of a co-operative management plan as formulated by the pastoralists are in Table 2.

Table 2. Actions and responsibilities of a co-operative management plan for *A. peuce* on Andado station and MCCR.

Management Action	Due Date	Andado station	PWSNT
Relocate North Bore to Eagle Bore site, and redrill East Bore.	30.06.04		Drilling rigs of Conservation & Natural Resources Group to undertake, operational costs carried by Parks & Wildlife Service.
Fence stands of *A. peuce* outside the proclaimed reserve.	30.06.04/ 30.06.05	Apply to Australian Government Envirofund ($30,000). Engage Traditional Owners from Aputula to erect fences.	Assist with application.
Set up Eagle Bore and shut down North Bore as a watering point for cattle.	30.06.05	Transfer pumping equipment, install tanks, troughs, and general infrastructure to Eagle Bore. Relocate yard structures to Olympic bore.	Cap North Bore
Set up East Bore with solar pumping array.	30.06.05	Apply to Australian Government Envirofund ($30,000) for funds for fencing, tanks, trough, and solar pumping array.	Assist with application.
Realign fences on proclaimed area to include all stands of *A. peuce*	30.06.06		Minor new works.
Relocation of cattle yards from North Bore to Olympic Bore complete	30.06.06	Purchase 300 portable cattle panels.	
Complete refurbishment of East Bore.	30.06.06	Apply to Australian Government Envirofund ($30,000) for funds for poly pipe and other minor infrastructure.	Assist with application.

OUTCOMES

- Joint agreement, all parties to do something to achieve a more viable future for the trees.
- North Bore capped, pastoralist gets alternative waters with a significant step taken towards the long term conservation of the trees, a great exchange.
- No real economic hardship – the return from the land area occupied by the fragments of the tree population is insignificant in terms of the area available for grazing, the pastoralist is able to re-locate stock yards.
- Peace of mind for the pastoralists as they are an integral part of the future management of the area of conservation significance.
- With Section 74 agreement, the conservation effort is carried forward should the current pastoralist family leave Andado.
- Nice for the pastoralists to contribute significantly to conservation on the property – it is frequently perceived that they don't really care.

REFERENCES

Anon. (1991). Mac Clark (*Acacia peuce*) Conservation Reserve: Plan of Management. Parks and Wildlife Commission of the Northern Territory. Unpublished Report. 46 pp.

Bowland, A.E. and Heywood, M. (2002). *The impact of cattle activity on the Northern Territory Waddy Wood* Acacia peuce *population.* Parks and Wildlife Commission, Department of Infrastructure, Planning and Environment, Northern Territory Government. Unpublished report. 12 pp.

Chuk, M. (1982). *The status and ecology of* Acacia peuce *in the Northern Territory.* Technical Report No.2, Conservation Commission of the Northern Territory, Alice Springs. 30 pp.

Deveson, E. (1980). *An inventory of* Acacia peuce *(F.Muell.) stands in Central Australia: Biogeography and ecology.* M.Sc. Thesis. Australian National University. 114 pp.

IUCN (2001). *IUCN Red List categories: Version 3.1.* Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, U.K.

Lennartsson, T. (2002). Extinction thresholds and disrupted plant-pollinator interactions in fragmented plant populations. *Ecology* 83: 3060-3072.

White, M., Albrecht, D., Duguid, A., Latz, P. and Hamilton, M. (2000). *Plant species and sites of botanical significance in the southern bioregions of the Northern Territory; volume 2: significant sites.* Report to the Australian Heritage Commission from the Arid Lands Environment Centre. Alice Springs, Northern Territory of Australia.

ENTERPRISE BASED CONSERVATION – CONSERVATION AS A COMMERCIAL LAND USE

E. Fessey [1], D. Green [2] and K. Kneipp [2]

[1] Bullabelalie', Brewarrina NSW 2839
[2] DIPNR, PO Box 342, Bourke, NSW 2840

ABSTRACT

To address equity in relation to the cost of conservation on privately managed land the Brewarrina Regional Vegetation Committee has developed a conceptual market-based instrument, termed 'Enterprise Based Conservation' (EBC), to address conservation requirements. Under the proposed EBC scheme, landholders enter a permanent contract to manage an area for conservation purposes and receive an economic return comparable to the value of the production that would have been generated from the previous landuse. The key is that economic returns are generated from an independent and self-sustaining conservation fund rather than the often unpalatable 'stewardship payments' that place a continuing demand on Governments.

Long-term conservation will result from a short-term investment by Government to establish a conservation fund. Estimates of a one-off cost of $500M (Morton 2002) have been made to provide for the conservation of 10% of the rangelands of Australia.

To help determine the eligibility criteria, conservation management contracts, mechanisms for allocating funds and the administrative framework for EBC, a pilot program has been established in the Western Division by WEST 2000 Plus.

Key words: Enterprise Based Conservation, rangeland conservation, alternative enterprises, conservation fund, Western Division, Market Based Instruments.

INTRODUCTION

To address equity in relation to the cost of conservation on privately managed land, the Brewarrina Regional Vegetation Committee developed a conceptual market-based instrument to achieve conservation. This instrument has been termed 'Enterprise Based Conservation' (EBC). Brewarrina Regional Vegetation Committee was a state government appointed community-based stakeholder group established under the NSW Native Vegetation Conservation Act 1997. Stakeholders included representatives of the Nature Conservation Council, NSW Farmers, Landcare, and NSW Government agencies.

Enterprise Based Conservation arose out of a desire to achieve a conservation target of 20% for the region to balance the development limit of 20%. More importantly, there is a need for the broader community to recognise the cost of conservation as a competing enterprise to the landholder. Enterprise Based Conservation promotes conservation as a legitimate commercial land use.

In principle, landholders voluntarily managing an area for conservation purposes, under a formal conservation agreement, would receive an economic return comparable to the value of the production that would have been generated from the previous landuse. It is important to note that the payments are not a series of handouts, but come from a fund that, once established, is self-generating.

The land conserved by landholders under EBC would be managed to an agreed standard and would be subject to similar management practices to other conservation areas, such as maintenance of fences, total grazing pressure management, noxious weed control, problem weeds, feral and pest control. Burning and grazing under approved conditions may also form part of the management plan but must be targeted for conservation outcomes. Essentially the landholder/lessee would deliver conservation products to an agreed standard of conservation management. If the land was not managed to the agreed standard, financial penalties would be incurred.

Long-term conservation will result from a short-term investment by the Government to establish a conservation fund. To initiate EBC, financial and administrative support is required from Government or private industry. In the longer term, conservation products would trade on the free market in competition with other commodity production.

The Western Division of NSW like other rangelands of Australia have a high retention of native vegetation, with grazing being the predominant land use. The management of many pastoral enterprises has provided native vegetation that is now considered to be in good condition. The value of this level of management and the retention of large areas of native vegetation has not been generally recognised. This is particularly so in regard to funding for natural resource management and systems of conservation. The Enterprise Based Conservation process enables landholders to receive recognition for management that has provided a certain level of conservation to date. It does this by providing a value for a higher level of conservation management in place of the current grazing production. This requires the conservation of land that is in reasonable condition under the current use and is proportionally representative to the vegetation communities of the general area. This is necessary to ensure all types of habitat are conserved and not only the poorer production country.

A PROGRESSION FROM COVENTIONAL METHODS OF CONSERVATION

To date landholders and the broader community have primarily recognised production values in agricultural enterprises. Current legislative and funding arrangements do not achieve long-term conservation that is a competitive land use to pastoralism. Enterprise Based Conservation allows conservation to have a productive value and be a competitive enterprise to agriculture. One of the major spin-offs would be the establishment of a drought proof alternative enterprise for the rangelands. With the concurrent reduction in drought funding required the system may work out to be cost neutral in the long term.

The commonly held view of political process is that each person gets their vote and elects politicians representing their views. The politicians then set broad goals for the 'public interest'. The government is in fact supposed to be managing the environment and economy for 'public good' (Abel and Tatnell 1997). If this were the current political process then the values attached to the rangelands of Australia would be demonstrated by the equivalent economic institutional input into long term conservation.

As is shown by this paper, conservation could be achieved over a large area of the landscape with a relatively small, one-off economic input from government. It is an opportunity for government to fund a process that will achieve conservation in the long-term and allow a change of agricultural enterprises to include conservation as part of their business. If land managers include conservation as part of their enterprise, conservation can be achieved across the landscape whilst maintaining the viability of the rural industry. This method also maintains a local knowledge base and has the potential to achieve more effective conservation than public conservation such as National Parks.

The comparison of perennial grass cover on park, off park and exclosed areas of the rangelands by Page *et al.* (1999) showed minimal difference in cover between on-park and off-park areas. However the exclosure areas had a considerably higher grass cover. The conclusions were drawn that total grazing pressure was the major factor affecting grass cover. Due to the current economic climate for rangeland landholders, it is unviable to remove stock and control grazing pressure without an alternate income source. Protected area managers are constrained by policy and community perceptions. Enterprise Based Conservation allows landholders to manage for conservation including total grazing pressure, resulting in better biodiversity conservation and prevention of land degradation.

A problem with current incentives for conservation is the reliance on landholder participation in a political climate that has caused a high level of distrust of government and a reluctance to commit to long-term conservation. Due to declining government services in rural communities, combined with general negative experiences, governments are distrusted and seen as 'outsiders' (Davies 1999). The most effective way for government to improve natural resource management and conservation is to facilitate approaches that are controlled by local people. Rangeland management is constrained by institutions and 'mental models', impeding thinking and acting on alternate uses (Abel 1999). Enterprise Based Conservation enables the landholder to have control and see conservation as another landuse in their property management.

Stakeholders in urban populations are hunters, campers, conservationists or consumers of water. Enterprise Based Conservation allows all stakeholders the opportunity to actively contribute to conservation of the rangelands (Abel 1999). The money contributed to a fund could be direct investments from urban populations or from industry offsetting the impacts of urban development. The difficulties in regional viability could be lessened with the investment from urban developers and populations.

Resource use on a regional scale is determined by a variety of factors including effects of past use, institutions, infrastructure, policies (e.g. drought relief) and enterprise level decisions (Abel 1999). Policies such as those relating to drought relief could be altered to allow a change in management and see a shift towards conservation and more conservative grazing management. Fluctuations in commodity prices and variation in rainfall emphasise the need for alternative and diverse uses in the rangelands.

PROCESS FOR ACHIEVING ENTERPRISE BASED CONSERVATION

The process requires that:

1. A Conservation Fund is established, using an initial contribution from government monies.
2. The current land use 'right' is purchased from the landholder. The purchase price is based on the current land use value as determined by a commercial land valuation. (In the Western Division the 'grazing rights' would be purchased from the current lessee.)
3. The money is invested in the Conservation Fund, rather than being paid directly to the landholder, and 'conservation shares' are allocated to the landholder. These 'conservation shares' are attached to the land title.
4. The Conservation Fund is available for the Government (initially) to borrow funds for infrastructure works. The Fund will be attractive to external borrowers/investors interested in environmental and/or ethical investments.
5. The lender pays commercial (or perhaps higher) interest on the loan, which is returned as a dividend to the landholder.
6. If the conservation area is managed to an agreed standard, the landholder receives a dividend based on a percentage of the market value of the land. For example, the landholder receives say an 8% dividend from the fund as payment for the conservation outcomes. If the areas were not managed to the agreed standard, the landholder would receive a reduced return.
7. Involvement by landholders would be voluntary.
8. Agreements would be considered permanent, however future change provisions could be incorporated where agreement was reached between both the landholder and the Conservation Fund administrators (initially the Government).

Example

- A Western Division landholder decides to manage 3,000 hectares (10% of the property) for conservation to an agreed standard.
- The Government purchases the grazing rights from the landholder who receives conservation shares attached to the property title.

- The purchase value of the grazing rights is invested in the Conservation Fund. (The average value of Western Division land is $30 per hectare, therefore, $90,000 is invested in the Conservation Fund).
- Money is borrowed by commercial or Government borrowers from the Conservation Fund with interest paid at commercial rates or a slight premium.
- The landholder manages the 3,000 hectares for conservation by destocking the area and managing it to maintain ground cover at or above 40%, which will encourage native grass, improve habitat, improve biodiversity, and enhance soil stability.
- In return, the landholder receives an annual 8% dividend from the Conservation Fund.
- The area would be perpetually managed for conservation, with dividend payments continuing in perpetuity.

COSTS FOR THE WESTERN DIVISON OF NSW

An investment cost of $96 million (invested in an accumulating capital fund) would result in around 10% of the Western Division or 3.2 million hectares being included in Enterprise Based Conservation. This could be implemented at an annual cost of $10 million over the next ten years. At an 8% return, this would generate $7.7 million drought proof income to the region as an alternative enterprise.

This is based on the following assumptions:

- Each year 1% of the Western Division is put in Enterprise Based Conservation.
- The market value of land identified for commercialising conservation is an average of $30 per hectare.
- The dividend paid on market value is 8% with a $2.40 per hectare return average.

ENVIRONMENTAL OUTCOMES

Like the Brewarrina Regional Vegetation Committee, the new Catchment Management Authorities (CMAs) will set targets for achieving conservation. To achieve targets set by NRM bodies such as the Western CMA in areas with high retention of native vegetation there needs to be an option for the landholder to receive an economic return for managing land for conservation. Without such an option it is not viable for rangeland landholders to have significant areas with no long-term economic return. Enterprise Based Conservation provides that option.

Short-term incentives have been available in the past. Those incentives have had minimal success in establishing areas of private conservation in rangelands of New South Wales. An alternative for such funds is to contribute to the establishment of Enterprise Based Conservation. The establishment of this instrument could achieve many of the natural resource management targets through landscape conservation and management.

The Western Catchment covers 23 million hectares in Western New South Wales. The catchment includes 20% of the Murray-Darling Basin and a large portion of New South Wales' rangelands. Table 1 shows some of the Western Catchment Blueprint targets and how Enterprise Based Conservation could contribute to their achievement.

A PILOT PROGRAM FOR ENTERPRISE BASED CONSERVATION

The principles of this scheme are already being trialed in the Western Division within a WEST 2000 Plus pilot program. The Western Division is an ideal location for Enterprise Based Conservation due to the largely unmodified nature of the rangelands, allowing for the planning of representative conservation areas across the landscape. This market-based tool could also be applied Australia wide. The pilot program will help to determine some of the detail of how Enterprise Based Conservation can be implemented in the long-term.

Table 1. How Enterprise Based Conservation could achieve the targets of the Western Catchment Blueprint.

Management / Catchment target of the Western Catchment Blueprint	How Enterprise Based Conservation (EBC) could contribute to the achievement of the Blueprint target
An ongoing program is established that allows landholders to incorporate land 'managed for conservation' as alternative land use and part of a viable enterprise	This target led from support of EBC and the support to implement it in the Western Catchment
Ecological communities of high conservation value are identified within 3 years of Blueprint approval and adequately protected throughout the catchment by negotiation with landholders	EBC would provide an instrument for conservation of high priority areas to be competitive with the existing use of the land
In any ecological community, areas cleared for change of land use are proportional to new areas managed for conservation in successive two year planning periods	To date the ability and willingness of landholders to manage areas for conservation has been limited. A system that recognises conservation as a competing land use would see a higher rate of conservation by landholders
Ecological communities of high conservation value are adequately protected Of the area of each other ecological community: • 12% is managed for conservation within 10 years and 25% within 25 years • no more than 35% in total is cleared	EBC provides realistic alternative to grazing that allows both high conservation value areas and representative areas of each ecological community to be conserved and protected
Quality and quantity of vegetation managed to maintain and/or improve designated cover capable of preventing soil erosion	The EBC process ensures areas are managed to agreed standards therefore improving quality of native vegetation
Sustainable Grazing Practice carried out by 100% of landholders within 10 years	An instrument such as EBC that has production returns for conservation management, economically gives landholders an opportunity to manage the remainder of their property at a sustainable level
No increase in the number of species or area of noxious or exotic weed infestation above current levels	Part of the management of areas under EBC is to manage noxious and exotic weeds therefore contributing to the achievement of the target
No increase in the impacts of pest animals above current levels	Pest animal control is part of the agreed management for EBC
Voluntary management of priority areas on Western Catchment rivers, leading to incremental improvement in native riparian vegetation	EBC would also encourage landholders to manage riparian areas for conservation allowing the improvement of western river systems

REFERENCES

Abel, N. (1999). Resilient rangeland regions. *Proc. VI International Rangeland Congress*, Townsville, Australia.

Abel, N. and Tatnell B. (1997). Rangeland imperatives – a view from Capital Hill. *Australian Rangeland Society Conference*, Gatton, Queensland.

Davies, J. (1999). More than 'us' and 'them': local knowledge and sustainable development in Australian rangelands. *Proc. VI International Rangeland Congress*, Townsville, Australia.

Morton, S. R. (2002). Biodiversity management and the Australian rangelands. *Proc. Australian Rangelands Society 12th Biennial Conference*, Kalgoorlie, Western Australia.

Page, M.J., Beeton, R.J.S. and Mott, J.J. (1999). Vegetation dynamics and the implications for protected area management in south-west Queensland rangelands. *Proc. VI International Rangeland Congress*, Townsville, Australia.

TOURISM AS A DRIVER FOR REGIONAL GROWTH AND DIVERSIFICATION

R. Greiner [1,3] *and M. Friedel* [2]

[1] CSIRO, PMB Aitkenvale, Townsville, QLD 4814
[2] CSIRO, PO Box 2111, Alice Springs, NT 0871
[3] Tropical Savannas CRC, Darwin, NT 0909

ABSTRACT

Tourism is a growth industry across most of Australia's rangelands. In some regions income from tourism outweighs income from traditional primary industries. However, tourism is not a silver bullet. Economic benefits are often off-set by social, cultural and environmental costs, and are distributed unevenly through communities. To achieve net benefits from tourism for communities, tourism needs to be planned and managed strategically. This paper outlines case studies in the Carpentaria Shire in north-west Queensland and in central Australia where research actively supports knowledge-based tourism development.

INTRODUCTION

Communities in Australia's rangelands have historically depended upon natural resources for income and employment. Specifically grazing and mining have been pillars of rangeland economies. More recently, tourism has emerged as another nature-based industry, as numbers of domestic and international visitors who travel to outback destinations increase. Tourism is in-principle complementary to other uses of the rangelands and offers great opportunities for diversification. Examples of on-farm tourism, mining tourism, conservation tourism and indigenous tourism abound across the outback (e.g. http://www.ntholidays.com.au). In some regions, such as central Australia, tourism is the major driver of economic development.

Tourism is generally promoted as a source of employment, revenue, additional tax receipts, foreign exchange benefits and enhanced community infrastructure. Yet while there are some clear benefits from an expanded tourism industry in remote regions, there are also some costs – primarily because tourism is dependent on and is a major user of natural resources and biodiversity. This is particularly true in the savannas, where rapidly increasing visitor numbers are straining resources, the environment, infrastructure, local services and the communities themselves.

Tourism, to be sustainable long-term, needs to generate net benefits for tourists, tourist businesses and host communities alike. This requires careful planning and management at all levels, including business, regional and national. This paper integrates and reports on two research projects, located in Carpentaria Shire in north-west Queensland and in central Australia, which are supporting rangelands tourism planning and management at the regional and business level.

STUDY BACKGROUND

Rangelands offer visitors an essentially nature-based tourist experience. Sustainable nature-based tourism requires that (1) the integrity of the natural environment is maintained and (2) all agents in the system generate net benefits: tourists, tourist businesses and host communities. To achieve sustainability, tourism planning and destination management need to build on a dynamic and integrated appreciation of tourism as a system, combining different stakeholder perspectives (Ko 2001). Furthermore, research aimed at developing that understanding must be integrated in relevant decision making processes.

The appreciation of tourism as a dynamic and integrated system with economic, social and environmental descriptors is central to both case studies. Although their analytical approaches and data gathering efforts are customized to address somewhat different questions, both depend on close engagement with their stakeholders.

Carpentaria Shire case study

The critical issue was to explore how the tourism market can be changed to maximise net benefits to the host community. Net benefits represent the total impact of tourism after integration of economic, social and environmental benefits and costs, which arise from the multiple interactions of tourists with a host community and region, and taking into consideration how those are distributed.

A systems approach to tourism was developed and applied (Greiner *et al.* 2003). The purpose of the systems model was to define, explain, and describe relationships among key variables. It served as a roadmap for data collection and interpretation for regional planners and managers who seek to develop tourism sustainably. The project completed five different surveys, collecting data on diverse socio-economic aspects of tourism in the region (Table 1).

Table 1: Summary description of survey methodologies

	Visitor survey	Community survey	Business survey	Consumer survey	Grazier interviews
Survey target	Tourists	Residents	Business managers	Shoppers (tourist and residents)	Graziers who diversify into tourism
Scope	Socio-economic profile, expectations, activities, preferences	Perceived economic, social and environmental benefits & costs of tourism	Employment, business income and expenses, location of transactions	Expenditure on groceries	Business profile, expectations, strategies, management issues
Sample size	510 travel parties (1400 tourists)	87 residents	24 businesses	128 total; 71 residents 57 tourists	6 pastoral lessees / managers

The research adopted a participatory action research approach with a high level of engagement of stakeholders – local government, tourist industry, community and planning bodies. Liaison was achieved through (1) consultation in the definition of research questions and project specification, (2) involvement in the data collection process, (3) regular interactions as well as briefings, presentations and discussions, (4) media coverage of the project and (5) collaboration in formulating the planning and management implications of the research outcomes.

Central Australian case study

A participatory action research approach was adopted for the central Australian study too. The objective was to develop the region's understanding of the tourism industry as a system and, using systems thinking methodologies, to enhance the region's capacity to respond to and plan for change. The purpose was to help the community identify options and strategies for increasing the benefits of tourism and devise practical tools and techniques that would help the region explore investment scenarios.

The first stage of the study engaged the central Australian community in workshops which captured their view of the industry in its regional context, showing how key issues were interconnected and what strategies might be applied to bring about change. From these, preliminary systems models were developed and populated with existing data. Application of the models demonstrated their potential as tools for testing investment scenarios. Subsequent scenario evaluation workshops enabled participants to run a number of scenarios in the model of their choice, exploring focused, diversified, lumped and staged investment strategies. Characteristics of the central Australian region are provided in Table 2.

RESULTS

Carpentaria Shire case study

Based on the surveys, there are an estimated 15,000 visitors per annum staying in commercial accommodation places in Normanton and Karumba (Greiner *et al.* 2004). Mean duration of stay is 20 days and estimated visitor nights total 300,000. Tourists come to Carpentaria Shire predominantly to fish and because of the mild winter weather (Greiner *et al.* 2003). Tourism is highly seasonal. The visitor market is almost exclusively domestic. Key tourist segments are retirees from southern states and 'groups of relatives and friends' and 'families' from north Queensland (Greiner *et al.* 2004). They are on low incomes (Stoeckl *et al.* 2004). Daily spending is low – of the order of ¼ and ½ of mean daily spending of overnight visitors to Queensland – yet they extract substantial natural resources from the region through fishing (Greiner *et al.* 2004).

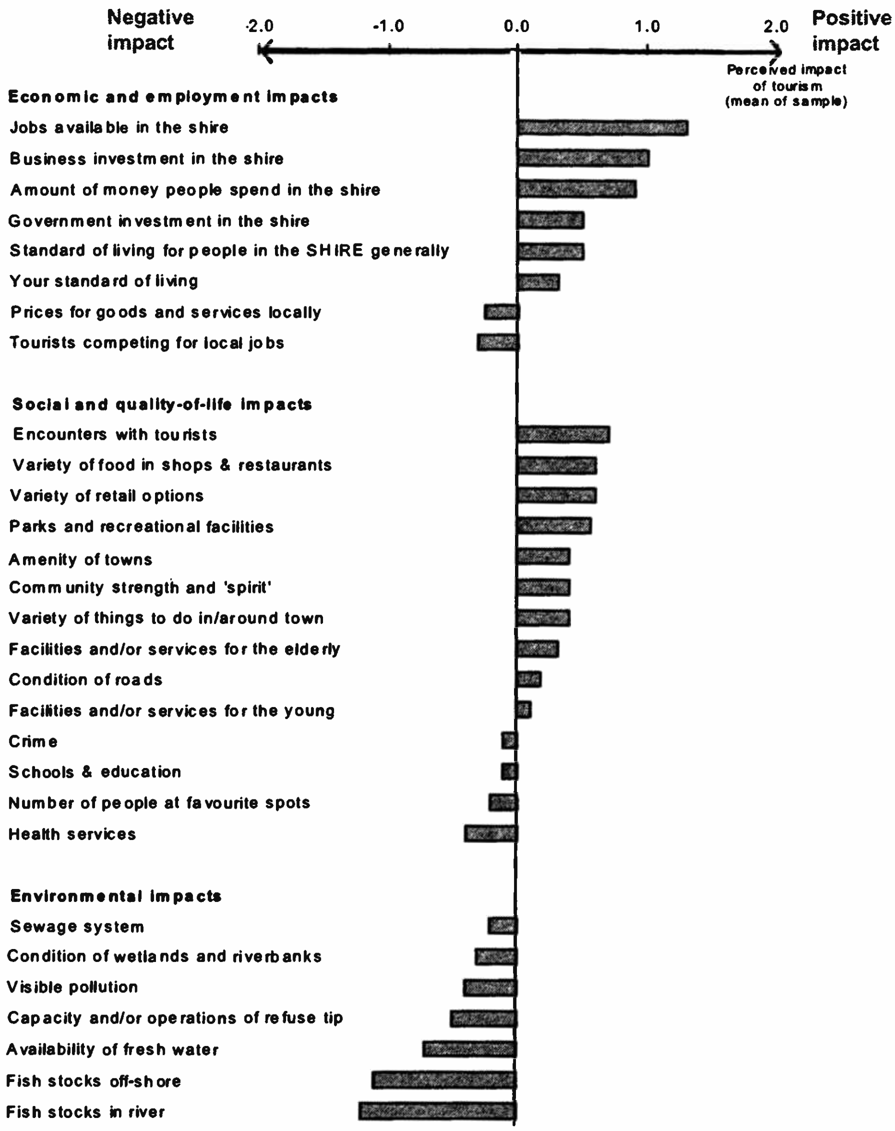


Figure 1. Impacts of tourism perceived by the community of Carpentaria Shire; means of total responses (Greiner *et al.* 2004; note: -2 highly negative, -1 slightly negative, 0 no impact, +1 slightly positive, +2 highly positive).

Tourist spending is approximately \$11.3 million and total economic impact is up to 25% larger than this. There are 180 persons employed in tourism – approximately 10% of the workforce or 15.9% of employment in the Shire – of which 7% are Aboriginal (Greiner *et al.* 2004).

The employment and investment benefits generated by tourism are clearly recognized by the host community (Fig. 1). Social impact is also largely seen as positive. However, these benefits currently come at perceived high to very high environmental costs. Despite this, 79% of respondents think that the benefits of tourism outweigh the costs. A detailed analysis of the responses detects very little variation of perception between different sectors of the community – across ethnic, age, professional or other social groups. People in Karumba, the main tourist place, perceive more negative impacts specifically in the lifestyle domain (Greiner *et al.* 2004).

Central Australian case study

Two models were developed, one addressing the different investment strategies that could be implemented in central Australia, and the second aimed at a more in-depth examination of the influence of market mix on the region. The first allowed users to explore the effects of investing in different combinations of five strategies (Fig. 2) while the second explored the impact of increasing visitor numbers on the market mix and tourism revenue. In scenario workshops most participants were keen on combining a number of investment strategies (focused, diversified, lumped and/or staged) to achieve smooth, sustained growth curves in tourism revenue and visitor numbers. Participants were also encouraged to reflect upon previous projects in the region, and assess them in terms of the investment strategy employed.

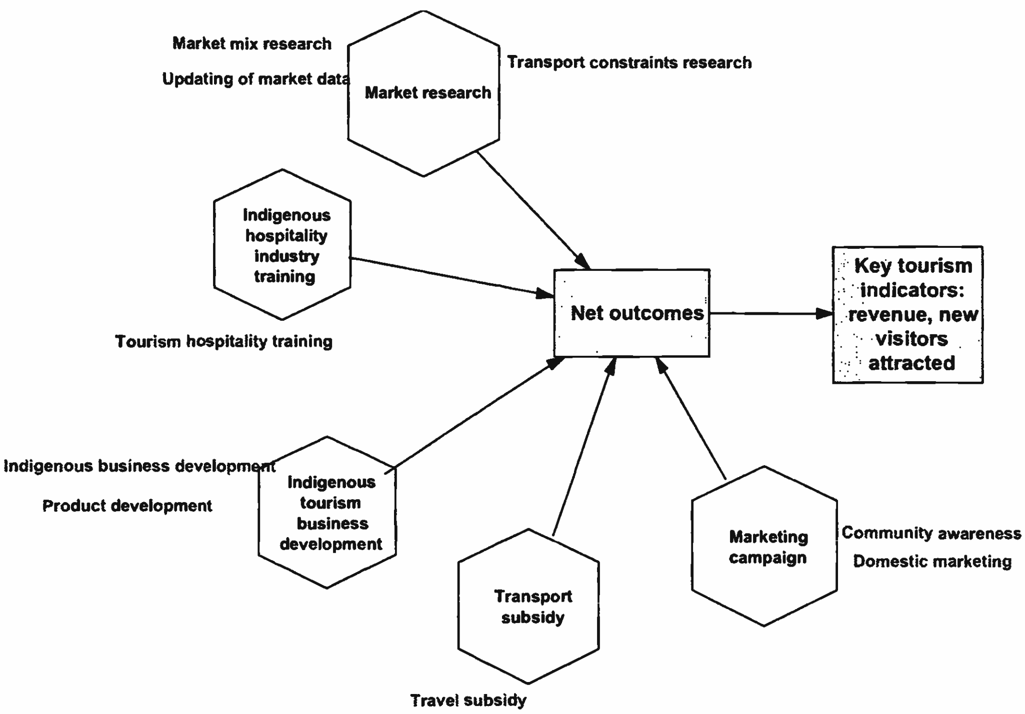


Figure 2. Components of the investment model: the 'gaming variables' are identified beside each sub-model and are those which the user can modify (invest in) in the course of running scenarios.

These models were limited to demonstration value, and had no real predictive power. Some areas of the investment model, e.g. indigenous training and business development, were particularly deficient in data. A second stage of this study will refine the preliminary investment models and develop an information system in collaboration with the tourism industry, government agencies and the wider community. Real-time data obtained through visitor surveys will provide information on visitor attributes, spending patterns and seasonality. This will enable realistic scenario testing of investment strategies for tourism in the central Australian region, so that the flow-on implications of different strategies can be recognized before implementation is attempted.

DISCUSSION

This paper develops understanding of tourism as a dynamic and multi-faceted system for two rangeland regions, which are very different. Those differences are summarized in Table 2.

Table 2: Summary description of tourist destinations: Carpentaria Shire and Central Australia.

	Carpentaria Shire	Central Australia
Size of region	69,000 sq km	546,000 sq km
Population (total, % indigenous)	4,000 60% indigenous	40,000 30% indigenous
Distance from nearest capital city	2,300 km (Brisbane)	1,500 km (Adelaide, Darwin)
Number of tourist businesses	27 (Normanton and Karumba only)	Approximately 150 (accommodation, B&Bs, caravan parks, galleries and tours)
Persons employed in tourism (% employment)	180 15.9% of regional employment	Not readily available
Value of tourism (pa)	Between $11.3 and 14.4 million	Direct visitor expenditure $404.5 million
Indigenous involvement in tourism	Very marginal; No indigenous tourist businesses; 7% of tourism workforce	Less than 5 owner-operated indigenous tourist businesses. Other information not readily available
Tourist market	97% domestic Retirees, couples, families, groups of friends	56% domestic, 44% international; Backpackers 8%, adventure travellers 22%, budget travellers 31%, nature-based travellers 16%, luxury travellers 13%
Seasonality	Peak season: June-September Off-season: October-March	Quarter ending September 34%, December 24%, March 17%, June 25%
Duration of stay	Mean: 20 days; retirees 77 days; singles 7 days	Mean: 3.1 days; e.g. visiting friends and relatives 6.7 days, business 3.6 days
Attractions	Fishing, weather	See icons (e.g. Uluru, Watarrka), outback experience, wildlife, World Heritage sites, adventures, Aboriginal culture, weather
Destination	Small part of 'Tropical North Queensland' and 'Outback Queensland' tourist destinations and NW-Qld tourist region; Integrated in 'Savannahway'	Central Australia (domestic market); or Uluru alone (international market)
Planning	Done from Brisbane (Tourism Queensland, Qld Gvt (e.g. NW-Qld tourism strategy) or Cairns (Gulf Savannah Development) Normanton: local initiatives slowly emerging: local museum/tourist information centre, environment centre	NT-wide: NT govt through NT Tourist Commission. Regionally: instigated by local industry/community and supported by NT government strategies e.g. Alice-in-Ten, and agencies e.g. NTTC

At the regional scale, tourism and options for tourism development need to be considered in a broader economic, community and environmental context. Data and understanding of relationships, which characterize the specific regional system, are required. Standard data collections such as the international and national tourism surveys provide good information on general trends and numbers, but are too generic to answer region-specific questions. Inevitably, regions need to design, conduct – and repeat – their own data collections to gain detailed insights into their specific tourist market, community perceptions and concerns, and business conditions and issues.

Grazing is the predominant land use across rangelands and an increasing number of graziers, too, are seeking to diversify into tourism. The reasons are manifold, ranging from income generation and risk management to overcoming social isolation. Yet tourism is no silver bullet at the business level either. Significant challenges arise for business planning and management if the venture is to be long-term sustainable. Impediments to farm-based tourism include leasehold land conditions, accessibility, size of potential market, and interference with prime grazing enterprise.

Many rangeland regions are 'peripheral' (Hohl and Tisdell 1995), as is the case for Carpentaria Shire. This brings specific challenges in terms of changing product, attracting different/more diverse tourist markets, adding secondary benefits (from money re-spent locally) and combating seasonality of visitation. Even where regions like central Australia are major destinations in themselves, similar challenges arise, especially when powerful market shocks like SARS and September 11 lead to sudden declines in particular market segments: strategies to ensure a diversified customer base and product are crucial.

For the learnings from research to be adopted into decision making, it is paramount that researchers liaise closely with tourism stakeholders. The extent of such interactions extends from formulating the key issues and questions to developing conclusions for investment, planning and management.

ACKNOWLEDGEMENTS

Funding was provided by Tropical Savannas CRC, Northern Territory Tourist Commission, Alice Springs Town Council and CSIRO Sustainable Ecosystems. We thank these organizations, the Carpentaria Shire Council, Gulf Savannah Development and Central Australian Tourism Industry Association. We also acknowledge with gratitude the significant contributions of our colleagues at CSIRO.

REFERENCES

Greiner, R., Stoeckl, N. and Mayocchi, C. (2003). Improving benefits from tourism to communities in Australia's tropical savannas. *In*, 'Proceeding of the International Conference on Modelling and Simulation' Townsville, QLD, 14-17 July 2003. (Ed. D. Post). The Modelling and Simulation Society of Australia and New Zealand, Canberra, pp. 1154-59.

Greiner, R., Stoeckl, N. and Schweigert, R. (2004). Estimating community benefits from tourism: The case of Carpentaria Shire. 48th Annual AARES Conference, Melbourne, 11-13 February 2004.

Hohl, A.E. and Tisdell, C.A. (1995). Peripheral Tourism: Development and Management. *Annals of Tourism Research* 22: 517-534.

Ko, J. (2001). Assessing progress of tourism sustainability. *Annals of Tourism Research* 28: 817–820.

Stoeckl, N., Greiner, R., and Mayocchi, C. (forthcoming). The financial and environmental impacts of different visitor segments: an empirical investigation of tourism in north west Queensland. *Tourism Management.*

Wall, G. (1997). Scale effects on tourism multipliers. *Annals of Tourism Research* 23: 446-450.

MULTIPLE AND JOINT USES ON PASTORAL LEASES: TENURE REFORM TO ACCOMMODATE THE MULTIFUNCTIONAL TRANSITION

John Holmes

School of Geography, Planning and Architecture, University of Queensland, Qld 4072

ABSTRACT

Already, major reforms have been implemented to land tenures and land ownership in Australia's rangelands, markedly restructuring the property, use and access rights awarded to major interest groups. These reforms are an implicit recognition of the transition towards multifunctionality, in which a complex array of consumption and protection values have emerged, displacing the former unchallenged dominance of production values. Further needed reforms are proving difficult to achieve, for reasons outlined in this paper. These reforms need to be pursued, not only to accommodate the increasingly important role of non-pastoral values but also to mitigate the structural problems which constrain rangeland communities from capturing the benefits of the multifunctional transition.

INTRODUCTION: THE TRANSITION TO MULTIFUNCTIONALITY

Multifunctionality refers to the fact that an economic activity may have multiple outputs and, by virtue of this, may contribute to several societal objectives at once. Multifunctionality is thus an activity-oriented concept that refers to specific properties of the production process and its multiple outputs (OECD 2001, 6).

The Ministerial communique (OECD 1998) recognises that, beyond its primary function of supplying food and fibre, agricultural activity can also shape the landscape, provide environmental benefits such as land conservation, the sustainable management of renewable natural resources and the preservation of biodiversity, and contribute to the socio-economic viability of rural areas (OECD 2001, 5).

Multifunctionality has become a buzz-word, narrowly defined to fit the policy imperatives of protectionist countries, notably the European Union and Japan, primarily intended to open up new modes of indirect agricultural support. Under WTO rules these 'non-commodity' outputs, grouped in the Green Box, can receive state-funded support, thus circumventing the agreed upper limits on direct production-specific and trade-distorting support, grouped in the Amber Box, with these now being approached in these countries.

Quite apart from its purpose in further corrupting trade in food and fibre, there are many additional problems with this narrow, production-oriented interpretation of multifunctionality. For an informed critique, see Potter and Burney (2002). For an Australian response, see Wynen (2002). To these provisos, I wish to add another, namely the pre-emptive hijacking of a useful term for a narrow policy goal, while also confining its application to 'the production process and its multiple outputs' (OECD 2001, 6). Consistent with this limitation, the report refers to forestry but not to forests, nor is there any recognition of multiple values (or 'outputs') from rivers, wildlife or other natural 'production' systems.

Equally important, this narrow designation fails to capture the critical change which has occurred in recent decades in western, market-oriented modes of rural land use, with the former dominance of *production* values being increasingly contested by the emergence of *consumption* and *protection* values. In interpreting this change in Australia's rangelands, I have previously followed the practice of UK rural researchers in describing this as a 'post-productivist transition' (Holmes 1997, 2002a). More recently I have proposed an alternative descriptor, namely the 'multifunctional rural transition', involving a more complex, contested, variable mix of production, consumption and protection goals (Holmes submitted). The growing importance of consumption values in shaping rural futures in favoured locales has recently attracted attention. In his report on structural change, commissioned by the National Land and Water Resources Audit, Barr (2002, 107) comments:

Currently, demand for landscape amenity is a major influence upon the pattern of structural change in Australian agriculture. The influence is manifest in the high price of land in the more amenable and accessible parts of the rural landscape. These higher land prices restrict the capacity of agriculture to adjust to maintain competitiveness and inexorably drive the path of adjustment to a non-commercial agricultural future.

Barr provides detailed evidence on the transition towards part-time or hobby or retirement farming in these locations, in response to the inadequacy of farm incomes and better access to non-farm income sources.

The rangelands of western U.S.A. are experiencing a parallel recent emergence of consumption values, now displacing commercial ranching from more favoured areas. This trend is accelerated by major population movements into rangeland states, attracted to high-amenity locations and with real-estate pressures being magnified by the limited availability of freehold land amid the extensive federal lands, held by the Bureau of Land Management and the National Forest Service. These pressures are contributing to the demise of full-time, commercial ranching on some of the most productive grazing lands (Knight *et al.* 2002).

THE TRANSITION IN AUSTRALIA'S RANGELANDS: STRUCTURAL PROBLEMS

As documented in my earlier overviews, Australia's rangelands are also experiencing a multifunctional transition, involving a radical shift from the former dominance of production values towards a regionally variable, contested mix of production, consumption and protection values. However, there are major structural differences when compared with either Australia's coastal areas or America's rangelands. Most strikingly, while these new values are powerfully reshaping future directions in our rangelands, they are providing meagre income streams or job opportunities, save in a few locations. In describing this as 'more value but less cash', I have discussed two significant structural problems. The first of these is the *shift towards non-market values*, including the restoration of indigenous customary resource use, preservation of biodiversity and of valued, semi-pristine landscapes, more emphasis on sustainability and on the greenhouse balance-sheet. The second is described as the *geographical transfer of value*, by which there is a 'functional and geographical disconnection of income streams from resource locale'. The economic benefits from emerging market-oriented, income-generating activities are captured by the cities, with few benefits to outback landholders or remote communities. This is the case most notably for fly-in-fly-out mining and mobile, self-sufficient safari-bus, 4WD, campervan and caravan tourism (Holmes 1997, 4).

NEEDED REFORM IN LEASE TENURES

At the 1996 Port Augusta rangeland conference, I sought to identify appropriate regional strategies to alleviate these structural problems (Holmes 1997, 20-24). At the 2002 Kalgoorlie conference, I addressed an entirely different decision context, namely reform of land tenure and land allocation to capture the benefits and minimise negative outcomes from the emergence of multiple uses and users of rangeland resources (Holmes 2002b, 63-67). My main proposals were: reactivation of the state's power to allocate and regulate non-pastoral resource-use, not only for lessees but also for third parties; expansion of public access routes and destinations; facilitating diversification of income streams for lessees; formulating protocols for collaborative arrangements between lessees and third-parties; enhancing the opportunity spectrum for footloose visitors, while minimising negative impacts; identifying trade-offs with lessees to selectively enhance their resource rights in return for enhanced protection of critical locales and ecosystems; and re-allocation of strategic land parcels to public ownership for multiple use, as with the American federal lands.

THE MOMENTUM TOWARDS REFORM

Some of these proposals may seem unrealistic. However, they should be viewed as merely a continuation of the recent, ongoing process of basic structural reform in land tenures, land allocation and property rights in Australia's rangelands. These reforms are being driven by the need to recognise the emergence of consumption and protection values alongside formerly dominant production values, consistent with the transition to institutionalised multifunctionality. Major elements in structural reform, already undertaken, are summarised in Table 1.

Of the proposals presented at Kalgoorlie, listed above, some initiatives have been undertaken. In all jurisdictions, governments have actively exercised their ownership of non-pastoral rights to facilitate diversification by lessees, but have been slow to award any of these non-pastoral rights to third parties. South Australia, Western Australia and Northern Territory have legislated to enable designation of public access routes on pastoral leases, but only in South Australia has any real progress been made. Only tentative moves have been undertaken in pursuit of trade-offs with lessees, enhancing their production-related property rights over select areas in return for protection controls over other portions of their leases. N.S.W. has taken the lead with a significant programme in its southern mallee zone, tied to cropping permits.

Prompted by the expiry of all pastoral leases in 2015, Western Australia has also been pursuing a number of policy initiatives in recognition of the multifunctional transition, with a strong emphasis on protection values. By far the most important of these is the exercise of the state's powers to terminate leases or to make exclusions from leases at time of renewal. The government has given notice of termination to 19 small leases in the South West Land Division and, of more significance, to four leases in the pastoral zone. Three of these are required for conservation purposes and the fourth for a number of purposes, including Broome townsite extension, conservation and Aboriginal interests. In addition, of the 512 pastoral leases, 97 have received notifications of exclusions of land required for conservation purposes. While occurring across all regions, the most extensive exclusions are in the Gascoyne-Murchison Region, where the regional strategy involves 10 to 15 percent of land to be held in conservation reserves. Lessees may have an ongoing role as managers or part-time rangers on these lands.

Of the other areas offering scope for structural reform, listed above, at this stage little further action has been formally proposed by government in W.A. However, following the first Gascoyne Muster, held in May 2002, five working groups were established 'to consider and make recommendations on important industry issues'. These groups were concerned with: sustainability; access to pastoral land; Aboriginal access and living areas; alternative models of land tenure; and pastoral industry economic monitoring requirements. The reports of working groups were discussed at the second Gascoyne Muster, held in October 2004. Also the reports were open to public comment until February 2004, after which the government has been considering further possible legislative changes, yet to be announced. At the first Gascoyne Muster, a wide array of issues was canvassed by all those in attendance, working in teams. On the theme of multiple use, diversification, public access and tourism, the issues receiving the most frequent mentions were: public liability; codes of conduct and public awareness; the rights of the lessee; damage to pastoral activity; and royalties and fees to lessees.

FUTURE DIRECTIONS

Not only in W.A. but in all jurisdictions, multifunctionality clearly remains on the policy agenda, with further moves to structural reform being inevitable. However, progress is likely to be gradual and reactive, save only when prompted by the exigencies of the legislative process, as with the termination of all leases in W.A. in 2015. This slow pace can be explained by the complexities in accommodating and reconciling diverse interests, particularly when seen to lead to potential disadvantage to the interests of the lessees.

Table 1. Changing directions in land ownership and property rights in Australia's rangelands.

Ownership, rights and duties	During productivist era	During multifunctional transition
Pastoral leases		
Rights of lessees	Progressively enhanced rights; greater security of tenure towards perpetual lease or freehold titles; but with continuing restrictions on non-pastoral activities	Limitations on rights towards ensuring sustainable use or recognising third-party interests; receding prospects for freeholding; but with greater freedom to engage in non-pastoral activities
Rents	Generally tied to livestock carrying capacity; progressive decline in rents, thus transferring asset value of land to lessee	Tied to land value, intended to ensure no further value-transfer to lessee and to recognise influence of non-pastoral uses on land value
Duties of lessees	Production-oriented: minimum stocking rates; development conditions, involving fencing, water-points and tree-clearing	Conservation-oriented: limitations on stocking rates; monitoring of range condition; controls on vegetation clearing and plant introductions
Rights of third-parties	Not recognised: lessee had exclusive possession save for limited public access and indigenous use in some jurisdictions	Exclusive possession denied in 1996 Wik judgment, recognising potential co-existing native title; further selective recognition of third-party access rights
Areal extent	Stable, embracing 42 percent of Australia's land area	Steadily declining, notably on marginal lands
Aboriginal lands		
Property rights on Aboriginal lands	None: land held mainly in government reserves	Substantial rights, including right to negotiate over mining activities; most land held under non-transferable freehold title
Common-law native title	Not recognised	Recognised in 1992 Mabo judgment and found to have survived in limited contexts
Indigenous rights on pastoral leases	Limited statutory access rights in only three jurisdictions (S.A., W.A., N.T.)	Some expansion of statutory rights; co-existing native title rights where traditional physical connection maintained (1996 Wik judgment)
Indigenous rights on conservation lands	Not recognised	Increasingly recognised, either as co-existing native title or as Aboriginal freehold with long-term lease-back to state, involving joint management
Areal extent of Aboriginal land ownership	Negligible	15 percent of Australia's land area, and expanding

Source: adapted from Holmes (2002a).

Another impediment to reform is the diffuse, fragmented, ill-organised representation of non-pastoral interests, incapable of exercising political influence commensurate with their prospective economic, social or environmental value within the rangelands. Also, of course, the lack of an appropriate institutional structure has a negative effect, not only in failing to accommodate these interests, but also in failing to mitigate the structural problems which militate against local capture of the social and economic benefits which can accompany the transition to multifunctionality.

REFERENCES

Barr, N. (2002). Structural Change in Australian Agriculture: Implications for Natural Resource Management. Australia: National Land and Water Audit: Theme Six. Website http://www.nre.vic.gov.au/agvic/profiles/clpr.htm

Holmes, J. (1997). Diversity and change in Australia's rangeland regions: translating resource values into regional benefits. *Rangel. J.* 19: 3-25.

Holmes, J. (2002a). Diversity and change in Australia's rangelands: a post-productivist transition with a difference? *Transactions: Institute of British Geographers* 27: 362-384.

Holmes, J. (2002b). Providing sites for shifting camps: land tenure reform to support the rangeland transition. Proceedings: Australian Rangeland Conference, Kalgoorlie. 63-68.

Knight, R.L., Gilgert, W.C. and Marston, E. eds. (2002). *Ranching West of the 100th Meridian.* Island Press, Washington, D.C.

OECD (2001). *Multifunctionality: Towards an Analytical Framework.* OECD, Paris.

Potter, C. and Burney, J. (2002). Agricultural multifunctionality in the WTO: legitimate non-trade concern or disguised protectionism? *J. Rural Studies* 18: 35-47.

Wynen, E. (2002). Multifunctionality and Agriculture: Why the Fuss? Current Issues Paper No. 13, 2001-2. Parliamentary Library, Canberra.

Environmental Risk Management
(Poster Group One)

IMPROVED SEASONAL FORECASTS FOR WOOL PRODUCERS IN WESTERN NSW

Y. Alemseged [1*], *R.B. Hacker* [1], *P.T. Hayman* [2], *P.M. Carberry* [2] *and B.K. Henry* [3]

[1] NSW Agriculture, Trangie Agricultural Research Centre, Trangie, NSW 2823
[2] NSW Agriculture, Tamworth Agricultural Institute, Tamworth, NSW 2340
[3] Queensland Department of Natural Resources and Mines, Indooroopilly, Qld 4068

INTRODUCTION

Western NSW, like the rest of the Australian pastoral zone, has experienced well documented land degradation associated with droughts (1879-1902, 1943-1945, 1960-1964 and 1982) (McKeon *et al.*, 2000). This degradation has taken the form of soil erosion, reduction of perennial forages and subsequent increase of woody species. Furthermore, the region is characterised by non-seasonal rainfall. This lack of strong rainfall seasonality creates difficulties in matching stocking rates with available forage. It also presents an opportunity for climate science to provide useful aids to management decision making, thus contributing to the financial and ecological sustainability of wool producers.

METHODS

We evaluated the skill of Seasonal Climate Forecasts (SCFs) in seven sub-regions of western NSW (Figure 1) to assess their potential to assist decision making by rangeland pastoralists. The probability of exceeding median (quarterly) rainfall or median (quarterly) pasture growth for various combinations of lead time (gap in months between the end of the period over which the indicator is measured and the start of the forecast period), forecast period (the time over which rainfall or pasture growth is forecast) and starting time (beginning of each month) was determined for both the Southern Oscillation Index (SOI) and Sea Surface Temperature (SST) phase systems. Both rainfall and pasture growth were computed for 5 x 5 km grid cells. Within each cell, skill was estimated by non-randomness in the distribution of above-median years across the SOI or SST phases, as measured by the chi-square (X^2) statistic. Forecasts were considered to have *useful* skill only if the probability of chi-square was <0.05 over at least 80% of the sub-region.

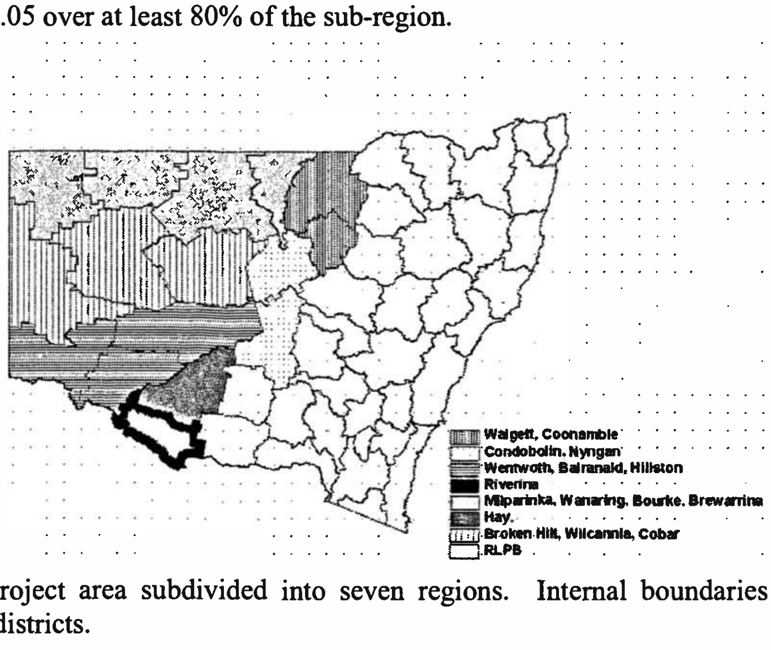
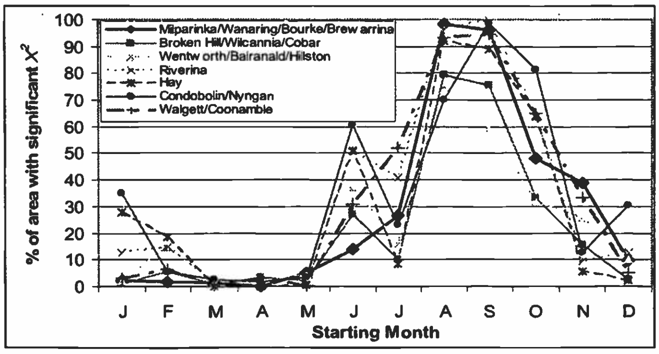


Figure 1. The project area subdivided into seven regions. Internal boundaries are Rural Lands Protection Board districts.

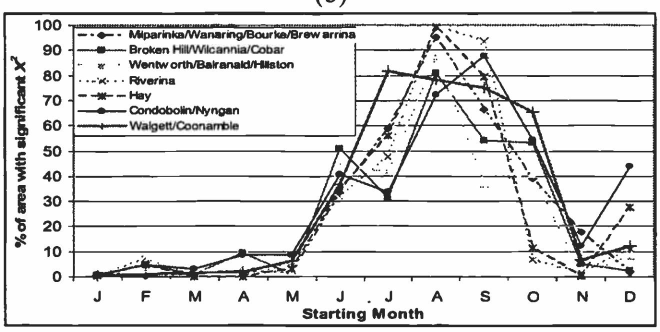
RESULTS

Only the SOI phase system had useful skill for any of the sub-regions, as assessed by our criteria. Within this system, forecasts related to pasture growth exhibited more skill than those related to rainfall, probably due to the integration of daily rainfall, temperature and evaporation in simulated pasture growth. The results of the skill analysis for the SOI phase system are presented in Figure 2 (a-c). Skill was higher in winter and spring than in summer and autumn, consistent with the timing of ENSO effects on rainfall in eastern Australia. Most regions exhibited useful skill (again by our criteria) for 0 and 1 month lead times in winter and spring but only two regions (Walgett/Coonamble and Condobolin/Nyngan) met the criteria for a three month lead time.

(a)



(b)



(c)

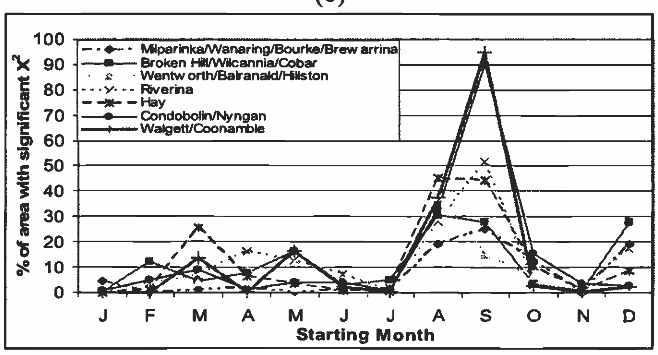


Figure 2. Skill of SOI-phase system in forecasting quarterly pasture growth in the seven regions of the project area. Skill is measured by the percent of area with significant X^2 values. (a) 0 month lead time (b) 1 month lead time and (c) 3 months lead time.

Monitoring of the SOI phase in winter and spring can assist management decision-making but its value is reduced during the more critical summer and autumn periods.

REFERENCES

McKeon, G., Ash, A., Hall, W. and Stafford Smith, D.M. (2000). Simulation of grazing strategies for beef production in north-east Queensland. *In* 'Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems, The Australian Experience'. (Eds G.L. Hammer, N. Nicholls and C. Mitchell). Kluwer Academic Publishers, Dordrecht. pp. 227-252.

DESERT FIRE: A DESERT KNOWLEDGE CRC PROJECT

Grant Allan [1], Glenn Edwards [2], Angus Duguid [2], Richard Tuckwell [3] and Nic Gambold [3]

[1] Bushfires Council NT, PO Box 2533, Alice Springs NT 0871
[2] Parks and Wildlife Service NT, PO Box 1046, Alice Springs NT 0871
[3] Central Land Council, PO Box 3321, Alice Springs NT 0871

Fire is a feature of the Australian landscape, within the vast desert regions, the northern tropical savannas and the southern coastal forests and heathlands. Its occurrence and impact within the desert regions is as variable as the region itself. Fire can be an annual feature of the northern desert regions fringing the tropical savannas, less regular in central Australia but closely linked to the variable rainfall, or completely absent in intensively managed grazing lands in the eastern arid zone. Attitudes vary towards fire, both in its value as a management tool and the threats and impacts of wildfires to infrastructure, productivity and biodiversity. These attitudes seem to vary locally and regionally, between and within community groups.

During the three year period 2000-2002, fires were common in the central and northern regions of Australia's desert lands, following a period of above-average rainfall that created exceptional grass growth and fuel production. This raised the awareness of fire but has also lead to conflicts among sectors of the rural community.

The Desert Knowledge CRC is attempting to address some of the key issues in managing fire in desert Australia through an initiative called *Desert Fire.* Desert Fire is a collaborative project involving key partners of the CRC (including the NT Government – Bushfire Council, Parks and Wildlife, and Biodiversity Assessment; Central Land Council; Charles Darwin University; and Adelaide University) and key stakeholder groups. Desert Fire is made up of eight sub-projects, linked together to meet a common goal.

The goal of Desert Fire is to "adapt and maintain appropriate fire regimes and their management based on robust research, planning, review and communication to support the diverse users and managers of desert lands to achieve a balance of their ecological, social and economic priorities".

There are a number of key issues to be addressed by the Desert Fire project. These include:

- quantification of the nature and extent of fires across desert Australia;
- evaluation of the factors which promote fires in desert Australia;
- identification of regions within desert Australia where fire management research is a priority;
- assessment of fire management issues in the Tanami Desert;
- examination of the impact of fires on biodiversity in desert landscapes;
- development of best practices for managing fire in National Parks, and
- assessment of the economic impact of fires in desert landscapes.

The following section provides a brief overview of each of the key issues that Desert Fire will address. In order to measure the nature and extent of fires it is necessary to build and maintain a good fire history database; recording where and when fires have occurred. In collaboration with the Tropical Savannas CRC, we have a broad scale continental fire history. It provides an initial overview of areas burnt during the seven-year period from 1997 to 2003. However its resolution and accuracy is restricted. It misses many small fires, and only identifies areas burnt, not the number of fires. Our project will help refine the continental fire history using hotspot detection of active fires. This will help identify many small fires that were not mapped and build a more complete national perspective of fire.

In combination with other information such as rainfall, land use and vegetation, an analysis of the fire database will evaluate the factors driving fires in desert Australia. The differences across desert Australia will improve our understanding of the system, our capability to predict wildfire risk (when and where fires may occur) and identify opportunities when fire can be used as a management tool.

The analysis will also help to select regional areas for more intensive investigation. Without pre-empting the analysis, our aim is to identify areas within each state and territory and to address issues that are both common and unique to each region. This will cover areas with differing combinations of land use and tenure, high fire frequency and the absence of fire. Based on our existing knowledge and experience we have selected the Tanami region of the NT as our first study area.

Within the Tanami there is a mix of land uses and economic activities, vegetation communities and fauna populations. It receives a relatively consistent annual rainfall that is linked to both regular fire opportunities and fire risk. We will discuss fire with people in the Tanami to involve the community in the project, to improve our understanding of the role of fire and the diversity of views and ambitions about fire. We recognise that fire can be a contentious issue and we hope that improving the dialogue about fire will help to resolve some conflicts associated with fire. To help us with this aspect we will compile a detailed fire history of the region to ensure a consistent interpretation of past events. The pattern of fire across Australia has changed since European settlement but the impact of this change is poorly understood and difficult to measure. However it has been identified as a contributing factor to many ecosystem changes, including the decline or extinction of medium-sized mammals within central Australia. We expect many other changes are also occurring. We will use our record of fires in the past three years, in combination with fire records over the past 30 years to study the impacts of fire on the biodiversity of the region. This will involve talking to people about plants and animals, and also doing flora and fauna surveys in the region to collect and count plants, insects, birds and small mammals.

National parks are areas where fire is a core part of land management practices and provide opportunities to study the differing effects of fire on plants and animals. Our work will include identifying species that are negatively affected by fire and developing guidelines for appropriate fire management of different vegetation types. It will also study the use of fire for conservation outcomes in ways that are efficient and compatible with neighbouring land uses.

We also want to improve our understanding of the economic impact of fires. It will not be possible to collect detailed information on all fires over the past three years, but we hope that a scattering of information from land managers across central Australia will help us to compile a more complete picture. We know that fires have damaged tourist infrastructure and affected tourist experiences, caused damage to pastoral infrastructure, cattle and pasture, affected mining operations and threatened Aboriginal communities and their natural resources. But we are also aware that some fires have had positive benefits to the management of woody weeds, improving pasture and providing employment opportunities in Aboriginal communities.

Our challenge is to engage community support for this work, demonstrate considerable progress and results during the first two year phase of the DK CRC, identify future needs and opportunities, and formulate further projects for the second phase of the CRC including collaboration with the Bushfire CRC. The ultimate goal of the Desert Fire project is to "promote the co-existence of fire, people and biodiversity in the desert landscape of Australia".

ASBESTOS GRASS (*Pennisetum basedowii*) IN NORTHERN AUSTRALIAN RANGELANDS

V. Alsemgeest [1] *and B.M. Alchin* [2]

[1] Dept Primary Industries Research Station, Roma Qld 4455
[2] University of Queensland, Gatton Qld 4343

BACKGROUND

Asbestos grass (*Pennisetum basedowii*) is an annual or short-lived perennial which occurs across northern Australia on floodplains and in Mitchell grass (*Astrebla* spp) pastures. It is most abundant in the Gulf country of north Queensland (it is also known locally as 'bastard grass'). Individual graziers and pastoral companies have expressed concern about the potential for asbestos grass to be a problem weed. An investigation was conducted into current knowledge of the species.

INVESTIGATION INTO ASBESTOS GRASS

This study involved a review of published material, liaison with government research and advisory personnel and a semi-formal survey with graziers and land managers. There is very little published material on asbestos grass.

Origin

The Queensland Herbarium has noted that asbestos grass is a native species. However, there is some conjecture about this, particularly as it belongs to the genus *Pennisetum*. Graziers have been observing changes in the location and density of this species for at least 30 years.

Distribution

Asbestos grass plants from Qld, NT and WA have been identified by the Queensland Herbarium. However, the specific distribution has not been delineated. General observations indicate it has spread significantly in the last 30 years. Prior to the 1974 floods, the species was very limited in its distribution in the Gulf country. Hall (1982) recorded a substantial increase in abundance after the floods. Asbestos grass occurs over an area of 400 sq km on one property in the Gulf country (12% of the holding). Its spread appears to be related to major flood/rainfall events.

Characteristics

Germination or new growth of asbestos grass occurs in November-January and it grows actively through December-February. Flowering occurs in late February-March, with seeds ripening by late March-April. It is dormant from May to November. Asbestos grass occurs as scattered individual plants through to extensive, dominant stands.

There is general recognition that asbestos grass is an undesirable species in pastures. The undesirability of the species is related to it being relatively unpalatable, its aggressive spread after major rainfall/flood events, and its apparent preclusion of more desirable species by forming dense swards. The level of palatability of asbestos grass may vary in relation to its phenological stage. Graziers have observed fresh growth being grazed. Its resistance to burning may enhance its competitiveness with more desirable species. Seed dispersal by wind, overland flow and attachment to animals ensures it is readily spread from parent plants. 'Whirly winds' appear to be an important dispersal agent in some regions. The seeds can cause eye problems with calves and sheep (Milson 2000). One grazier noted that this caused extreme irritation with calves and resulted in an opaque blue film developing over the eye. It is sometimes necessary to manually dislodge these seeds at branding time.

Whilst the main spread of asbestos grass appears to relate to flood/rainfall events, the plant density in existing stands changes annually. This is presumably related to its relatively short life cycle. Break down of dead plant material is relatively slow.

Impact

Asbestos grass appears to be an 'increaser'; its abundance increases as rangeland condition declines (Milson 2000). Whilst concern has been expressed about asbestos grass, there is no quantification on its impact on the environment or pastoral productivity. If the extensive swards on some of the large holdings in the Gulf occurred on smaller holdings, the economic impact could be very serious.

Specific observations on the impact of asbestos grass include: reduction of productivity of associated species in the pasture; cattle will not walk through dense stands and it is very difficult to ride motorbikes through dense stands. The holding paddock on one property is now completely dominated by asbestos grass. This may indicate a relationship between the grazing regime and increase in asbestos grass.

Feral pigs favour asbestos grass areas as habitat, but they do not cause long term damage to the stands.

Management

Depletion or loss of vigour in the more desirable pasture species may enhance the spread of asbestos grass. There is consideration that grazing by *Bos indicus* breeds may be more conducive to increasing the vigour and spread of asbestos grass than *B. taurus* breeds. However, it is probable that this relates more to grazing management rather than breed. Overgrazing may also result in increased run-off and consequent localised flooding; the latter would be conducive to further spread of asbestos grass.

There has been no specific management to control asbestos grass on the properties where there is concern about its impact. This is partly because of economics, but also because of its known lack of response to fire, as well as the lack of knowledge of plant response to management inputs.

RECOMMENDATIONS

There is sufficient evidence to indicate that asbestos grass may pose a potential problem if it continues to spread. It is recommended that a research project be established to study the basic biology and ecology of the species. Research into management could include the response of asbestos grass to intensive grazing in its early growth stage. Although it is difficult to burn, fire should be considered as a possible management tool (at least for containment of dense stands).

On-going Survey

The authors are still gathering information on this species – contributions would be appreciated.

REFERENCES

Hall, T. (1982). Species associations in a grassland on a heavy cracking clay in north-west Queensland: their structure, soil associations and effects of flooding. *Aust J. of Ecology* 7: 249-259.

Milson, J. (2000). *Pasture Plants of North-West Queensland.* DPI Qld. pg. 279.

MOUND SPRING ECOSYSTEMS IN THE WESTERN AUSTRALIAN RANGELANDS

S.J. Black

CMAE, c/o PO Box 51, Wanneroo WA 6946

INTRODUCTION

As permanent sources of water within arid and seasonally dry landscapes, mound springs provide refuge habitat for flora and fauna, and historically have been a focus for Aboriginal culture and European exploration. In addition to their significant ecological diversity and cultural values, this distinct group of wetlands is recognized for its geological features and value to science. Occurring at natural discharge points for groundwater, these ecosystems are characterized by mounds; rare landforms built up by sediments transported to the surface, such as clay and/or calcareous precipitates, as well as accumulated peat from onsite vegetation.

In Australia, mound springs are best known from the edges of the Great Artesian Basin, which spans central and inland eastern Australia. Also known to occur on the Swan Coastal Plain near Perth, and in the northern Wheatbelt region, the existence of mound springs in the rangelands of Western Australia (WA) is poorly documented. This paper provides a broad overview of their biotic and abiotic features, anthropogenic processes threatening the springs and conservation management requirements. It highlights the need for these wetlands to be managed holistically, as part of surface water catchment areas and as groundwater dependent ecosystems, and through coordinated long-term projects.

FEATURES

Extant mound springs of WA's rangelands are currently known from the Kimberley Region, and in and on the edge of the Great Sandy Desert, both inland and on coastal intertidal mudflats. They occur singularly or in clusters of up to around 20, separated by several metres, kilometres or tens of kilometers, and are known from at least 11 areas and five bioregions. In contrast to those of the Great Artesian Basin (and one now extinct example on the Pilbara coast), these wetlands contain organic mounds comprised entirely of peaty soils, rather than calcareous tufa. Rising as high as two meters above the surrounding landscape and ranging up to several hundred meters across, the mounds are generally surrounded by a moat of fresh or brackish water. Carbon dating and pollen records from core samples at two mound springs in the Great Sandy Desert show that deposition of organic sediment has occurred at the sites uninterrupted for at least the last 6,000 years, pointing to general groundwater and climatic stability over this time (Wyroll *et al.* 1986).

Mound spring vegetation ranges from sedgeland-herbfields, to *Melaleuca* forests, to *Sesbania* woodlands, and to the State's southern-most occurrences of monsoon vine thickets. In addition to some unusual species assemblages, interesting flora records include inland occurrences of the mangrove *Avicennia marina*, an undescribed sedge species, one priority species *Utricularia aurea*, and several northern Australian species, including trees, which are not recorded from elsewhere in the State. Utilized by a variety of vertebrate fauna, the Kimberley mound springs also stand out as relatively rich aquatic habitats for invertebrates. Those sampled to date contain a high proportion of northern species and a strong Indo-pacific or Asian element, particularly among the micro-invertebrates. Several described species were first records for the State.

THREATS AND CONSERVATION MANAGEMENT

Situated in remote areas on pastoral stations, Aboriginal reserves, Unallocated Crown Lands, and proposed conservation reserves, mound springs are highly vulnerable and at risk from a range of threatening processes, acting directly on the ecosystem and/or indirectly on the groundwater and other hydrologic and landscape processes upon which they depend. Current impacts are, or derive, from:

overgrazing, trampling and fouling by cattle and feral camels; severe gully erosion; inappropriate fire regimes; weed invasion; horticulture; invasion by feral fish; feral pig damage; dumping of litter, and; groundwater aquifer contamination through concentrated stock access and septic tank effluent. A serious potential risk is aquifer drawdown by proposed groundwater resource developments (current proposals exist for groundwater irrigated timber plantation and cotton farming enterprises).

Conservation management implemented to date has included: the fencing of several springs by pastoralists, LCDCs and other community groups with Natural Heritage Trust funding; some survey and documentation and listing as threatened ecological communities; capping of a free flowing bore; acquisitions by State Government for addition to the reserve system, and; the development of environmental water requirements in State Government water allocation and planning processes. However, management has been sporadic – limited by the availability of resources, subject to short-term funding and delayed by difficulties in achieving management agreements between stakeholders.

Three urgent onsite priorities for the management of mound springs are: (1) more fencing; (2) immediate repairs and an ongoing commitment to regular maintenance of existing fencing, and; (3) erosion control works – onsite, in the immediate area, and at strategic locations within broader catchments. These operations can be problematic, expensive, labour intensive and subject to delays due to: the remoteness of mound spring locations; the location of some of them on intertidal mudflats or inland salt flats (subject to periodic inundation and salinity); the extremes of tropical climates (cyclone, fire and flood damage), and; pressure on the fences by free ranging cattle and feral camels.

So far, mound spring wetlands have been fenced individually with little or no buffer zone. Similarly, the majority of proposed acquisitions to the reserve system are limited to the immediate area of wetlands. Ideally, larger areas should be sought to enclose groups of springs and maximize buffer areas around them, in order to address gully erosion (a landscape scale process) and to reduce animal pressure on fences in the immediate area of wetlands. However, this ideal is currently dependent on the willingness of pastoralists and incentives to pastoralists to alter their management, enter into joint management agreements, or sell off larger parcels of land than previously.

More strategic fencing and vehicle access track alignments are required in relation to topography and surface water flow patterns, as well as animal behaviour. For example, fencelines and tracks running down slope are likely to cause gully erosion on fragile soils, particularly where animals form pads along them in their attempts to access wetlands for water and green feed. Fencing has been most successful in two instances where water was pumped from the spring (by solar pump) to a water tank and trough well outside the fenced area. This also satisfied the pastoralist by maintaining a quality water source and preventing cattle from bogging.

There is a requirement for research on, and monitoring of, the ecology and ecosystem processes of mound springs, including groundwater regimes and requirements, and the likely impacts of change, as well as management (or lack of) on the ecology. It is essential to monitor groundwater levels and flow rates at springs where abstraction is proposed, and responses where abstraction is proceeding.

Despite recent increased interest in mound springs and their conservation, these outstanding ecosystems are still in the process of degradation and destruction, and at risk from future threatening processes. Their integrity and survival will depend on long term coordinated commitments to funding and management with partnerships between government land and water management agencies, pastoralists, Aboriginal and other local people, Aboriginal organizations, and community groups.

REFERENCES

Wyrwoll, K.H., McKenzie, N.L., Pederson, B.J. and Tapley, I.J. (1986). The Great Sandy Desert of Northwestern Australia: the last 7000 years. *Search* 17: 7-9.

RABBIT CONTROL – REDUCING THE IMPACT OF THE DROUGHT IN SOUTH WEST NSW

S. Bradford and R. Rees

Rangeland Management Action Plan, PO Box 305, Wentworth NSW 2648

ABSTRACT

Rabbits have been a major problem creating overgrazing and increasing the impacts of drought in the rangelands. Rabbits have the ability to eat 100-150 g of food per day, which when a doe can produce over 100 rabbits in a breeding season, stock are competing with rabbits for available feed. The South West Rabbit Control Group and the WEST 2000 program have been running a successful rabbit warren ripping program over the last six years, since 1996. The programs have worked with Landcare groups, and Rural Lands Protection Boards covering the Western Division of New South Wales. Participating properties have mapped paddocks treated and recorded the number of warrens ripped, hours taken to complete the project, and cost per hectare treated.

The rabbit warren ripping program with the South West Rabbit Control Group and West 2000 has demonstrated the benefits of a rabbit warren ripping program. The development of the project has prompted other groups in Australia to conduct similar projects. Public and environmental benefits of the program have continued to become evident over the running of the project, particularly during the drought, as the impact from rabbits has been decreased.

INTRODUCTION

The South West Rabbit Control Group (SWRCG) was a project developed in September 1996 to have a coordinated and regional approach to rabbit control and take full advantage of the rabbit eradication opportunity presented by the release of Rabbit Calicivirus Disease (RCD). In the south west of the Western Division of New South Wales, rabbits are recognised as one of Australia's greatest environmental pests and detrimental to pastures and native vegetation. Rabbits eat plants, shrubs and grasses, which are more palatable, and nutritious with higher water content, all vegetation species desired by stock (Gooding 1955).

The South West Rabbit Control Program ran in the south west of NSW from September 1996 to May 2002. A management plan and guidelines were developed to implement a coordinated approach to rip warrens over the 1.8 million ha of the South West Rabbit Control Group area. The aim of the project was to reduce rabbit numbers and capitalise on RCD (Croft 1997). Guidelines and standards for machinery were put in place, with landholders having completed property maps to record treated areas. West 2000 Plus has continued to provide landholders with incentives to complete rabbit ripping.

Most landholders initially underestimated their rabbit problem. After taking part in the program, they have a greater awareness of damage caused by rabbits and the benefits arising, not only to the environment but benefits to drought management.

PROJECT RESULTS

Since the commencement of the project in September 1996, the South West Rabbit Control Group has ripped a total of 309,627 warrens in the region, with an additional 52,204 warrens ripped under the West 2000 project, with properties still completing work with West 2000 Plus funding. Project totals (Table 1) indicate the average cost per warren and the total cost to carry out the project, which was funded on a dollar for dollar basis.

Table 1. SWRCG project totals September 1996 – May 2002

Project Totals	Warrens	Hours	Cost ($)	$/Warren
SWRCG	309,627	26,399	2,336,274	$7.59
West 2000 Plus	52,204	6,205	490,753	$9.40
	361,831	32,604	2,827,027	$7.85

CONTROL BENEFITS

Many properties in the South West Rabbit Control Group area have continued to control rabbits, regardless of the drought and lack of finances as they have realised the benefits that destroying rabbit warrens gives to their property. The reduction of rabbits provides some relief of total grazing pressure on properties, and therefore provides a head start when the drought breaks.

Environmental benefits

To determine the benefits of the rabbit-ripping project, a study was undertaken to collect information and data from a limited number of field sites in western New South Wales. The data collected on rabbits and the diversity of plants in relation to rabbit warrens were compared with similar data from Yathong Nature Reserve near Cobar. The study confirmed that the activity of rabbits results in reduced diversity of vascular plants, and the grazing of rabbits also produces major impacts on shrubs and trees, through reduced recruitment (Eldridge 2002). Results of the study indicated that ripping of rabbit warrens is a highly effective control method. Results also show that Rabbit Calicivirus Disease (RCD) is not sufficiently effective as a sole method of rabbit eradication. The rabbit warren ripping project has demonstrated on properties that the land has a greater cover of different grasses which had not been seen for years, along with trees returning naturally as evidenced by pine, belah and apple bush that are regenerating.

Production Benefits

The benefit of the rabbit ripping program to the grazier has been an improvement in stock management and productivity rather than to run more stock. The reduction in rabbit numbers has resulted in an increase in available feed particularly in drought conditions, as on some properties with a ripping program, the drought has taken much longer before affecting the property. Decreasing grazing pressure and improving environmental condition has lead to better wool cuts and higher lambing percentages. Domestic stock can be rotated around paddocks as the feed levels drop off, knowing grazing pressure by rabbits has been reduced and forward paddocks have not been depleted of ground cover and desired palatable pastures.

CONCLUSION

Rabbit numbers are at an all time low in some areas due to the combination of the rabbit ripping program and RCD. Even during the drought landholders continued to control rabbit populations. With their properties destocked, carrying out ripping program was seen as beneficial as results of such a project were becoming evident. The coordinated approach to the project and co-operation of property owners in the region resulted in the project exceeding the expectations when originally established. Although further and more detailed studies are required to assess the impact of rabbit activity on reptiles and small mammals, information from landholders, while qualitative, provides an understanding that rabbit control has benefited some properties, including during the drought.

REFERENCES

Croft, D. (1997). South West Rabbit Control Group Rips Into Warrens. SWRCG Final Report.

Eldridge, D. (2002). The Impact of the European Rabbit (*Oryctolagus cuniculus L.)* on diversity of vascular plans in semi – arid woodlands. Consultancy Report for West 2000.

Gooding, C.D. (1955). Rabbit damage to pastures. *Journal of Agriculture* 4: 753-755.

AUSSIE GRASS: AUSTRALIAN GRASSLAND AND RANGELAND ASSESMENT BY SPATIAL SIMULATION: NEW DEVELOPMENTS AND APPLICATIONS

J. Carter [1], D. Bruget [1], K. Day [1], R. Hassett [1], B. Henry [1], and in collaboration: I. Watson [2], R. Cowley [3], S. Heidenreich [4], J. Leys [4], J. Maconochie [5], G. McKeon [1] and A. Peacock [1]

[1] Natural Resource Sciences Centre, DNRM&E, Indooroopilly Qld 4068,
[2] CMAE, WADA, Northam WA 6401,
[3] DBIRD, Katherine Research Station, Katherine NT 0851,
[4] Centre for Natural Resources, DIPNR, Gunnedah NSW 2380,
[5] Dept. Water, Land and Biodiversity Conservation, Adelaide SA 5001

INTRODUCTION

Calibrating a continental scale spatial model running at a daily time step is a challenging task. There are about 270,000 pixels for which a calculation is made. Parameters have to be estimated for about 186 pasture communities. Data for model calibration and validation fall into three main classes: (1) ground based observations, (2) satellite based observations and (3) production statistics. Model calibration and validation from all three classes of information are continually being improved and we firstly describe this recent work and then briefly outline application of the model to climate research.

GROUND BASED OBSERVATIONS

Pasture biomass

Pasture biomass observations can be used to test that the model correctly simulates pasture biomass. Because measurements are made at a point, many observations are needed to produce data suitable for model calibration. By the end of 2003 about 500,000 individual observations of pasture biomass had been collected by the AussieGRASS team using the method described in Hassett *et al.* (2000). Observations now cover many regions of Australia. Northern Australia and some other regions have good time series of observations. Biomass alone is not a good model constraint as it is the result of a number of processes (growth, herbivory, detachment and burning), and therefore needs to be combined with other types of measurements. Pasture utilisation in tussock grasslands can be visually estimated by observing tussock shape to give an estimate of utilisation. Using utilisation in qualitative and quantitative manner for model calibration will force model parameters to differentiate between high-growth-high-removal and low-growth-low-removal scenarios that result in the same biomass. Visual checking of Queensland data suggests that at a regional scale predicted patterns of utilisation match observations.

Ground cover

Total cover observations from rangeland monitoring sites in NSW, field surveys and from high resolution satellite data have been used to calibrate total cover as produced from the model. The challenge is to ensure that the observed and simulated cover are measurements of the same thing and that there are enough cover measurements over time and space to ensure that the resulting calibration can be applied at regional rather than point scale. Cover data from calibrated Landsat TM images across Queensland will provide a large increase in the amount of cover data available. Model estimates of cover can now be produced for Australia but are well calibrated only in western NSW.

Hydrology

AussieGRASS simulates all major components of the water balance. Validation of model runoff against measured stream flow provides a coarse validation of the model water balance. AussieGRASS now regularly produces an output of potential flow to stream as a percentile and as a forecast.

Estimates of long-term average rainfall and evapotranspiration are closely correlated with those empirically estimated by Zhang *et al.* (2001).

SATELLITE BASED OBSERVATIONS

The Normalised Difference Vegetation Index (NDVI) is widely used for ecological purposes. It is an index constructed from reflected light in the red and near-infra red parts of the spectrum. The NDVI data series (from the Advanced Very High Resolution Radiometer (AVHRR) time series is temporally dense (10-14 days, in cloud free areas), and has a long time series (nearly 20 years). The NDVI signal is rich in information (Carter *et al.* 2002), and can be used to constrain model parameters. Used alone NDVI provides only partial information about plant growth. Satellite measurements of surface temperature combined with air temperature data provide additional information about evapotranspiration. The differential between air and surface temperatures is directly related to the rate of evapotranspiration. Use of both NDVI and thermal data is improved by decomposing AVHRR composite data into images for individual days and correcting for bidirectional reflectance effects. Radar scatterometer data for land surfaces have the potential to provide information on surface soil moisture and potentially on pasture biomass (Jarlan *et al.* 2002). The spatial extent of these data is low, (about 500 sq km) but data are available every 1-3 days. This allows detection and monitoring of change such as bare soil drying after rainfall. This system is best suited to arid areas and indications are that soil moisture simulated by the AussieGRASS model is well correlated with satellite derived estimates. Soil moisture estimates from AussieGRASS can be now made available for input to a Global Climate Model to improve model initialisation prior to forecast runs.

PRODUCTION STATISTICS

Statistics from the grazing industry can be used to check and calibrate model outputs. These data are useful at Statistical Local Area (SLA) to national scale. Wool production is perhaps the easiest to use at the SLA scale. Time series data of meat production are much more difficult to use (even at the State scale) in calibration because of lack of spatial integrity due to significant local and interstate movement of animals for fattening and slaughter. Knowledge of stocking rates and animal outputs can be used to ensure pasture growth is at least sufficient to provide for the observed animal production. Research aimed at predicting animal production is underway. In addition it is now possible to estimate methane emissions from livestock for greenhouse gas inventory purposes.

CLIMATE DATA AND APPLICATIONS

Climate records for the period 1890 to 1957 have not been available on a spatial basis due to the low number of stations available as digital data. The *Computerising the Australian Climate Archives* (CLIMARC) project has yielded digital data from an additional 50 stations back to about 1900. Interpolated surfaces of the new data are being generated and checked. AussieGRASS now has the capability to run an increased array of climate forecast systems and can produce statistical probability maps for different forecast systems.

REFERENCES

Carter, J.O., Bruget, D., Hall, W.B. and Collett, L. (2002). Using satellite data to calibrate a continental scale model of pasture production. *In*: Proceedings 11th Australasian Remote Sensing and Photogrammetry Association Conference, Brisbane, pp 831-840.

Hassett, R.C., Wood, H.L., Carter, J.O. and Danaher, T.J. (2000). A field method for statewide ground-truthing of a spatial model. *Australian Journal Experimental Agriculture* 40: 1069-1079.

Zhang, L., Dawes, W.R. and Walker, G.R. (2001). Response of mean annual evapo-transpiration to vegetation changes at a catchment scale. *Water Resources Research* 37: 701-708.

Jarlan, L., Mougin, E., Frison, P.L., Mazzega, P. and Hiernaux, P. (2002). Analysis of ERS windscatterometer time series over Sahel (Mali). *Remote Sensing of Environment* 81: 404-415.

A RIPPING YARN: THE EFFECT OF RABBIT WARREN RIPPING ON PLANTS AND SOIL

David J. Eldridge, Carly Costantinides and Adam Vine

School of Biological, Earth and Environmental Sciences, University of NSW, 2052

BACKGROUND

The European rabbit (*Oryctolagus cuniculus*) is one of the most damaging environmental pests in Australia. Over much of their range, rabbits live in large underground warrens. Large amounts of soil are excavated to form an elevated mound, and warren excavation leads to extensive and prolonged soil disturbance (Eldridge and Simpson 2002). Rabbit activity also destroys woody vegetation (Lange and Graham 1983), and continuous grazing results in increased grazing pressure, reduced pastoral productivity and eventually landscape degradation. While the ripping of rabbit warrens is a popular technique for controlling rabbits, little is known about its effect on the vegetation and soils. We report here the results of a number of studies to assess the impact of ripping on soils and vegetation, and the degree of invasion on ripped and unripped warrens.

METHODOLOGY

The study was undertaken at Yathong Nature Reserve in western NSW. Five microsites were examined along a gradient through each of ten ripped warrens (centre, mid centre, edge, near control, far control). Soil cover (litter, plants by species, cryptogam cover, bare soil) and microtopography were assessed, and soil samples taken for germination in the glasshouse to examine soil seed banks. Two-hundred warrens (100 intact, 100 ripped) were surveyed, and plant cover, number of active and inactive entrances, and warren area measured. Multi-variate analysis (Multi-Dimensional Scaling, PRIMER; Indicator Analysis; PCORD) was used to examine relationships between seed banks and ripping status and warren microsite. Analysis of variance and non-parametric statistics were used to look for differences in reinvasion of ripped and unripped warrens, and to test for differences in soil cover and species diversity between ripped warrens and non-warrens.

RESULTS

The cover of bare soil declined and cryptogam cover increased with increasing distance from the warrens. Ripped warrens had a more degraded soil surface (more scarps and bare soil) compared with control surfaces ($P<0.001$).

There were substantial differences in plant species composition between the warren centre, edge and non-warren control sites ($P<0.019$). Significantly more species were recorded at the warren edge followed by the control sites (Table 1). Three (weedy) species (*Schismus barbatus, Salsola kali* var. *kali* and *Chenopodium melanocarpum*) were highly indicative of degraded warren surfaces (Indicator Value 56-72%, $P<0.007$). *Austrostipa scabra* was a strong indicator of non-warren surfaces (IV=63%, $P=0.008$). The structure of the soil seed bank differed significantly between the warren microsites and the controls (Global $R=0.713$, $P=0.001$). Ripped and unripped warrens differed significantly in their complement of plant species (Global $R=0.815$, $P=0.001$). Forty-four species (30,188 individuals) emerged from the soil seedbank, with two species (*Crassula sieberana* and *Schismus barbatus*) accounting for 66% of all germinants.

Unripped warrens contained approximately ten-times more active warren entrances ($F_{1,98=}$ 328.18, $P<0.001$) and reduced plant cover ($F_{1,198}=63.58$, $P<0.001$) compared with ripped warrens. Larger warrens generally had more burrows ($F_{1,198}=73.21$, $P<0.001$, $R^2=0.26$)

Table 1. Diversity of seeds germinating from the soil seed bank in relation to warren microsite. SE is standard error of the mean; different subscripts within a row indicate a significant difference in that component at P=0.05.

Component	Warren centre		Warren edge		Control	
	Mean	SE	Mean	SE	Mean	SE
No. of species	12.8^a	0.65	17.1^b	0.86	15.8^c	1.5
No. of individuals	278.0^a	59.0	339.0^a	50.0	317.0^a	65.0
Richness	2.19^a	0.15	2.84^b	0.13	2.62^b	0.20
Evenness	0.50^a	0.06	0.58^a	0.03	0.53^a	0.04

DISCUSSION

Our results demonstrate marked biotic and abiotic differences between rabbit-disturbed and adjacent rabbit-free woodland. Taken together, these results reinforce the view that rabbits have a negative impact on surface soils and vegetation in semi-arid woodlands. Differences in the composition of the plant community were reflected in marked differences in the germinable soil seedbank between the warren and non-warren microsites.

The germinable seed bank on ripped warrens was dominated by weedy exotic species (e.g. *Schismus barbatus*), and our results indicate that ripped warrens are not likely to regenerate in the short-term given the paucity of desirable plant species in the soil seed bank. Restoration of the vegetation is highly depended on reinstating the natural surface morphology, which is primarily an intact biological crust.

Our results indicate that there are likely to be large differences between ripped and unripped warrens in their complement of plant species, although results are based on only five years of recovery after ripping. Little is known about post-disturbance succession of plants on ripped warrens, but anecdotal evidence suggests that it is at the scale of many tens of years. Active intervention may therefore be necessary to hasten recovery in good years. Our work reinforces the need to destroy warrens, which will only continue to act as harbour for rabbits if left intact.

REFERENCES

Eldridge, D.J. and Simpson, R. (2002). Rabbit (*Oryctolagus cuniculus* L.) impacts on vegetation and soils, and implications for management of wooded rangelands. *Basic and Applied Ecology* 3: 19-29.

Lange, R.T., and Graham, C.R. (1983). Rabbits and the failure of regeneration in Australian arid zone *Acacia*. *Australian Journal of Ecology* 8: 377-81.

INTEGRATIVE TECHNOLOGIES FOR ASSESSING THE EXTENT AND CAUSE OF DEGRADATION IN ARID COMMUNITY RANGELANDS IN INDIA

M.H. Friedel [1], *S. Kumar* [2], *G.N. Bastin* [1], *U.R. Ahuja* [2], *B.K. Mathur* [2], *D.K. Saha* [2] *and P. Narain* [2]

[1] CSIRO Centre for Arid Zone Research, PO Box 2111, Alice Springs NT 0871
[2] Central Arid Zone Research Institute, Jodhpur-342 003, India

BACKGROUND

Over 200,000 sq km or 60% of Rajasthan is arid, and forms 62% of the Indian arid zone. Annual rainfall spans 100-350 mm, is largely monsoonal and highly variable, and grazing is the major land use. Meat, wool and milk underpin the economy, while crop production is opportunistic and for subsistence only. The human population is increasing by about 30% every decade and is currently about 20 million, of which 80% are rural dwellers. Livestock numbers are also growing and recent estimates stand at about 11 million Adult Cattle Units (ACU). They are being sustained on a gradually shrinking area as irrigation canals encroach on the grazing lands and degradation increases; the area available per ACU is currently about half what it was 40 years ago. The rural landscape is also being pressured indirectly by expanding urban populations which depend on rural areas for animal products. Presently, there is little quantitative information about the spatial extent and severity of the degradation problem, nor is there capacity to feed back to villagers and district administrators quantitative information about the impacts that land uses are having or the effects that management changes might have. Due to the lack of appropriate tools for land management decision making, effective contingency planning has not evolved.

OUR OBJECTIVES

1. To apply and adapt Australian-developed techniques, using remotely-sensed data, for assessing land degradation, to Indian desert environments.
2. To gather ground-based survey data on socio-economic factors, the natural resource base and animal production for interpreting the results of remotely sensed analyses.
3. To develop means of information exchange with village communities and district administrators in order to explain land degradation.
4. To develop capacity with Indian colleagues for their independent use of all methodologies.

We are integrating knowledge of ground-based field ecology, livestock production and socio-economics in western Rajasthan with remote sensing and GIS skills from central Australia to develop degradation assessment technologies, as a first step towards improving land management.

SUMMARY OF OUTCOMES

Our study is centred on four villages some 80 km west of Jodhpur. Humans are inextricably linked with land condition and this project has an emphasis on understanding how socio-economic factors contribute to land degradation, as determined from satellite and ground-based biophysical data.

Remote sensing and vegetation attributes

Satellite images acquired prior to, and following, three contrasting wet seasons were used to estimate multitemporal vegetation cover. Land degradation was then indicated by the extent of vegetation response to monsoon rains (resilience values, Bastin *et al.* 1996). Results of image analysis were verified with vegetation and soils data collected at field sites.

Livestock and socio-economic data

Livestock, social and economic information was collated from 25 respondents in each of four villages (primary data) and extracted from national census data (secondary data). Some important findings which impact on land use are:

- size of land holdings:– 66% are 1.3-4.8 ha (marginal to small farmers), 29% are 8.6-21.6 ha (medium to large farmers), and holdings are often fragmented;
- numbers of large animals are increasing slowly (7.7% over 5 years) while numbers of sheep and goats, which are hardier, are increasing rapidly (44.3% over the same period);
- average family size is 7.6, but marginal farmers have the largest families (10.6); and
- low literacy levels – men (50%), women (< 10%) – plus early marriage contribute to high population growth.

Data integration with GIS

Remote sensing outputs, digitised maps, ground-based vegetation and soils data, and survey data were combined in a GIS to assist data interpretation (example output shown in Fig. 1).

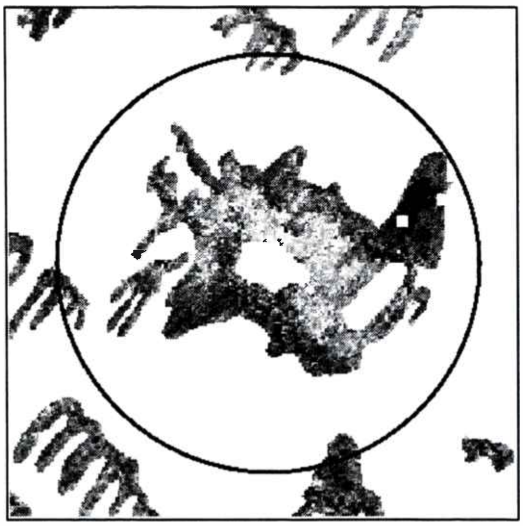


Figure 1a. Degradation status of grazing lands as indicated by resilience values within five km of Shergarh village. Darker areas are more resilient. White squares are locations of field validation sites.

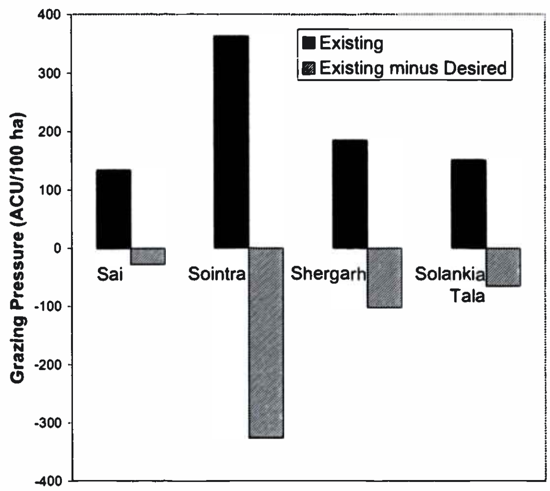


Figure 1b. Disparity between existing and desired grazing pressure at four surveyed villages.

Information exchange

Community entry was achieved through building on previous contacts by CAZRI scientists. Villagers welcomed veterinary advice on diseases and nutrition, veterinary prescriptions and provision of saplings free of cost. Honoraria for informants were unsuccessful because they alienated people who did not receive them. The implementation phase of the project will involve scaling up remote sensing products to assist administrators assess degradation at district or regional scale and target management.

Infrastructure and capacity building

The project has established a remote sensing and GIS laboratory at CAZRI, and acquired equipment, software and imagery. Indian scientists have gained expertise in field methodology, use of equipment, and image processing and interpretation during exchange visits with Australian colleagues. Scientists have also undertaken GIS training to ensure that they can use the project GIS independently.

ACKNOWLEDGEMENTS

We gratefully acknowledge the support and funding provided by ACIAR. We also thank our agencies ICAR and CSIRO, and our colleagues, for their support.

REFERENCE

Bastin, G.N., Pickup, G., Stanes, J. and Stanes, A. (1996). Estimating landscape resilience from satellite data and its application to pastoral land management. *Rangeland Journal* 18: 118-135.

IMPROVED CLIMATE FORECASTS FOR AUSTRALIA'S WOOL PRODUCERS

B. Henry [1*], *D. Bruget* [1], *J. Carter* [1], *D. Cobon* [2], *N. Flood* [1], *R. Hacker* [3], *G. McKeon* [1], *A. Peacock* [1], *M. Truscott* [4] *and I. Watson* [5]

[1] Queensland Natural Resources, Mines and Energy; 80 Meiers Road, Indooroopilly, 4068
[2] Qld DPI&F; [3] NSW Agriculture; [4] SARDI; [5] WA Department of Agriculture

INTRODUCTION

In order to minimise resource damage and enhance long-term productivity, pastoralists need improved seasonal forecasting knowledge and tools to better manage for the high climate variability that characterises Australia's rangelands. Issues affecting adoption of seasonal climate forecast (SCF) information include a (real or perceived) lack of regionally specific forecasts at times when key management decisions have to be made, and limited confidence in existing operational systems. Rather than seeking to identify forecasts that matched the existing timing of decisions, the initial approach adopted in this multi-state project funded by Land, Water and Wool (LWW) was to establish a system to test if and when SCF systems have skill in the major pastoral regions of Australia. Four State-based projects then investigate the extent to which wool producers could take advantage of this climate forecast information in management decisions (see posters by Alemseged *et al.* and Watson, this conference). This approach has the advantage of addressing to some extent the risk of 'unrealistic expectations' on the part of producers and uses the flexibility that exists in pastoral enterprises, particularly in terms of managing stock numbers. However, it does not address the lack of a clear link between operational SCF systems and publicly available reports on probability of an El Niño or La Niña developing. Therefore, a second approach using recent understanding of the relationship between indices of Pacific Ocean oscillations and climate variability in Australian rangelands is also being evaluated for potential to deliver useful longer lead climate forecast information to wool producers.

EVALUATING SEASONAL CLIMATE FORECAST INFORMATION FOR PASTORALISTS

Monthly outputs of probabilities of exceeding long-term median rainfall and simulated pasture growth from the AussieGRASS spatial model form the basis of a project website to evaluate SCFs. A range of forecast periods and lead times throughout the year are considered. Variations in within-season rainfall can result in large variations in growth, and simulations of pasture growth that integrate daily rainfall and other climate and environmental data generally provide a better and more robust assessment of seasonal conditions (e.g. Stafford Smith and McKeon 1998). Hence, probability of exceeding median pasture growth was considered a more useful measure of seasonal outlook than rainfall alone.

The SOI phase (Stone *et al.* 1996) and the 9-phase SST (Drosdowsky 2002) systems that produce three-monthly forecasts have been extended in this evaluation framework (*LWW Map Arranger*) to consider longer lead times and forecast periods than available operationally. Expansion to include other SCF systems is also under development. A simple skill test (Chi square) is calculated spatially in association with each forecast, and statistical methods can be applied to select forecasts that have regional significance. This subset of forecasts can then be assessed within each region relative to the management of pastoral properties. Testing was successful in identifying forecasts with potential to support some management decisions. For example for western NSW Alemseged *et al.* (this conference) illustrate forecast skill with the SOI phase system being useful in winter/spring with lead times of up to three months. In western Queensland the forecast period of most importance for wool producers is summer (November to March) and using the SOI phase system, useful forecasts were identified for this 5-month period with up to one month lead, i.e. using the August-September phase.

A limitation of operational SCF systems is that they do not currently offer sufficient lead time to support those management decisions that have to be made 6 to 12 months ahead. Further, there is as yet no information on the risk of multi-year droughts which have had such an important impact on environmental and economic sustainability of grazing enterprises. In the future new SCF systems now being developed and tested will address some of these issues (e.g. Day *et al.* 2000, White *et al.* 2003). There is also an emerging capability to predict development of El Niño or La Niña conditions using Global Climate Models (GCMs), and a growing understanding of the relationship between SSTs in the Pacific Ocean and rainfall in Australia. This capability has resulted in increasing public discussion of probabilities of an El Niño developing, especially during the 2002 drought. We explored the potential for using forecasts based on El Niño–Southern Oscillation (ENSO) predictions from the International Research Institute for Climate Prediction (IRI) for climate risk management in pastoral enterprises.

COMPOSITE FORECASTS USING ENSO AND INTER-DECADAL PROBABILITIES

Probabilities of ENSO conditions have been interpreted in terms of the probability of exceeding median rainfall or pasture growth in the rangelands of Australia. Years from 1890 were classified as El Niño, neutral or La Niña using SOI values, allowing an overall *composite* probability of rainfall exceeding the long-term median to be calculated based on current year-type. The advantage of this approach is that it provides a longer lead forecast that is consistent with public reports and that can be updated rapidly in response to changing probabilities of an El Niño developing. We are assessing this new approach, including how to handle the small differences in SOI-based classification of years as El Niño, neutral or La Niña compared to the IRI ratios of 25%, 50%, 25%, and possible conservative nature of the forecast.

Studies (e.g. McKeon *et al.* 2004) have shown an interaction between ENSO indices (e.g. SOI) and indices of inter-decadal variability in the Pacific Ocean. Indices of SOI for Jun.–Nov. and the Pacific Decadal Oscillation (PDO) for Dec.–Feb. were used to classify historical years into six year-types: 1. El Niño – *warm* PDO; 2. El Niño – *cool* PDO; 3. Neutral – *warm* PDO; 4. Neutral – *cool* PDO; 5. La Niña – *warm* PDO; and 6. La Niña – *cool* PDO. The Dec.–Feb. PDO was chosen because it showed no significant correlation with SOI for the coming year but allowed the development of a composite forecast for rainfall using the PDO phase available at the end of summer and monthly updates from the IRI of ENSO probabilities for the year ahead. Predictions of simulated pasture growth for each year-type were based on starting conditions (including soil moisture, surface cover, pasture biomass and grass basal area). Interestingly, El Niño – *cool* PDO years were often associated with below average rainfall and pasture growth over large areas of the rangelands. La Niña – *cool* PDO years appear to most often provide good opportunity for recovery. There was some evidence for trends in these year-types over the last hundred years with the former becoming drier and the latter wetter. Preliminary analyses have been made of the relationship between SOI – PDO year-types and historical drought periods but a major challenge is whether extreme droughts or sequences of dry years can be predicted. In summary, the new 'composite' approach to providing climate information based on SOI – PDO year-types indicates a potential for longer lead forecasts that are consistent with publicly available information. Continued evaluation in collaboration with regional projects will indicate whether this approach could facilitate adoption of SCF information by wool producers for improved management of climate variability in the rangelands.

ACKNOWLEDGEMENT

The funding support of the Land, Water and Wool climate sub-program is gratefully acknowledged.

REFERENCES

Day, K.A., Ahrens, D.G., Peacock, A., Rickert, K.G. and McKeon, G.M. (2000). Climate tools for northern grassy landscapes. *Proc. Northern Grassy Landscapes Conf. Katherine.* 29–31 Aug 2000. pp. 93–97. CRC for Tropical Savannas.

Drosdowsky, W. (2002). SST phases and Australian rainfall. *Aust. Met. Mag.* 51: 1–12.

McKeon, G.M., Hall, W.B., Henry, B.K., Stone, G.S. and Watson I.W. (Eds) (2004). *Pasture degradation and recovery in Australia's Rangelands: Learning from History.* NRSc Publishing, NR&M, Qld.

Stafford Smith, D.M. and McKeon, G.M. (1998). Assessing the historical frequency of drought events on grazing properties in Australian rangelands. *Ag. Sys.* 57: 271-99.

Stone, R.C., Hammer, G.L. and Marcussen, T. (1996). Prediction of global rainfall probabilities using phases of the Southern Oscillation Index. *Nature* 384: 252–55.

White, W.B., McKeon, G.M. and Syktus, J.I. (2003). Australian Drought: The Interference of Multi–Spectral Global Standing Modes and Travelling Waves. *Int. J. Climatology* 23: 631–62.

MODELLING *Parkinsonia aculeata* INVASIONS AT THE CATCHMENT SCALE

R.A. Lawes [1,2] *and L.V. Whiteman* [1]

[1] CSIRO Sustainable Ecosystems, Davies Laboratory, Townsville, Qld 4814
[2] CRC for Australian Weed Management

ABSTRACT

To effectively manage weeds, information on the individual species' distribution and habitat is required. Both habitat and distribution can be described at a range of scales. In this study the objective was to describe and understand the distribution of *Parkinsonia aculeata* within the Cape River catchment of North Queensland. Generally, *P. aculeata* occupies flood prone and riparian areas. An aerial survey for *P. aculeata* was conducted to ascertain the weed's distribution in the Cape River catchment. More *P. aculeata* was found in the downstream portion of the catchment. Following this survey, habitat characteristics were derived from Landsat imagery and soil surveys using a geographic information system. The distribution characteristics of the weed were also derived using neighbour methods. A classification and regression tree was employed to determine which habitat and spread variables influenced the distribution of *P. aculeata* within the Cape River catchment. Generally, the presence of *P. aculeata* was influenced by spread characteristics, soil type and the proximity of the weed to the riparian zone. The model may be used to facilitate catchment scale management of *P. aculeata* and this is discussed.

INTRODCTION

Parkinsonia aculeata is an invasive woody weed that, under favourable conditions, can grow 7 m high. It is found in the rangeland areas of the Northern Territory, NSW, Queensland, South Australia and Western Australia. *P. aculeata* generally invades riparian zones and flood prone areas and is principally spread by water.

To successfully manage *P. aculeata* its spatial distribution must be considered at the catchment scale and knowledge of the weed's distribution throughout a catchment is useful. In this study, catchment scale information distribution of *P. aculeata* was combined with habitat and spatial information to build a predictive model of *P. aculeata* invasion for the Cape River catchment of North Queensland. The model outputs can help devise a rule based catchment scale management strategy for *P. aculeata.*

METHODOLOGY

The principal rivers and associated tributaries of the Cape River were aerially surveyed and the presence of *P. aculeata* recorded with a GPS. This process is described in detail elsewhere (Lawes *et al.* 2003). The Cape catchment had previously been surveyed and data were available for soil type and geology. These data were transferred to a 500 m grid and allied with the *P. aculeata* survey data.

For each *P. aculeata,* six spatially explicit variables were calculated. These included the distance to its nearest neighbour upstream, downstream and in any direction. The number of instances when *P. aculeata* was present upstream, downstream and in any direction at 1 km, 5 km and 10 km were also calculated. Other variables included the distance from the river and distance from the mouth of the Cape River. A regression and classification tree was employed to describe the distribution of *P. aculeata* in the catchment in relation to habitat and spatial variables.

RESULTS

Parkinsonia aculeata has invaded a relatively small portion of the catchment and was present at only 708 of the 7947 grid positions surveyed. The error rate of the model was small, at 6.04% and was achieved because the model correctly predicted *P. aculeata* absence. There were only 177 false positives. *P. aculeata* presence was harder to predict, with only 462 of the 708 *P. aculeata* locations correctly predicted. There were 11 nodes to the regression and classification tree and six possible pathways through the tree (Figure 1). Of these, one indicated that *P. aculeata* would be present on 71% of occasions and another that it would be present on 43% of occasions. The remainder resulted in either low (<16%) or very low (<1%) chances of *P. aculeata* presence in the Cape River catchment. No pathway predicted *P. aculeata* absence with 100% accuracy.

P. aculeata was present at a given location (71% accuracy) if all the following criteria were met:

- There were at least 3.5 instances where *P. aculeata* was present within 1 km.
- The given location was situated on either a clay to loam soil, or close to the river.
- There were at least 19.5 instances where *P. aculeata* was present within 5 km.

Alternatively, *P. aculeata* was present at a given location (43% accuracy) if:

- There were less than 3.5 instances where *P. aculeata* was present within 1 km.
- There was still *P. aculeata* present within 600 m.
- The given location was less than 250 m from the river bank.

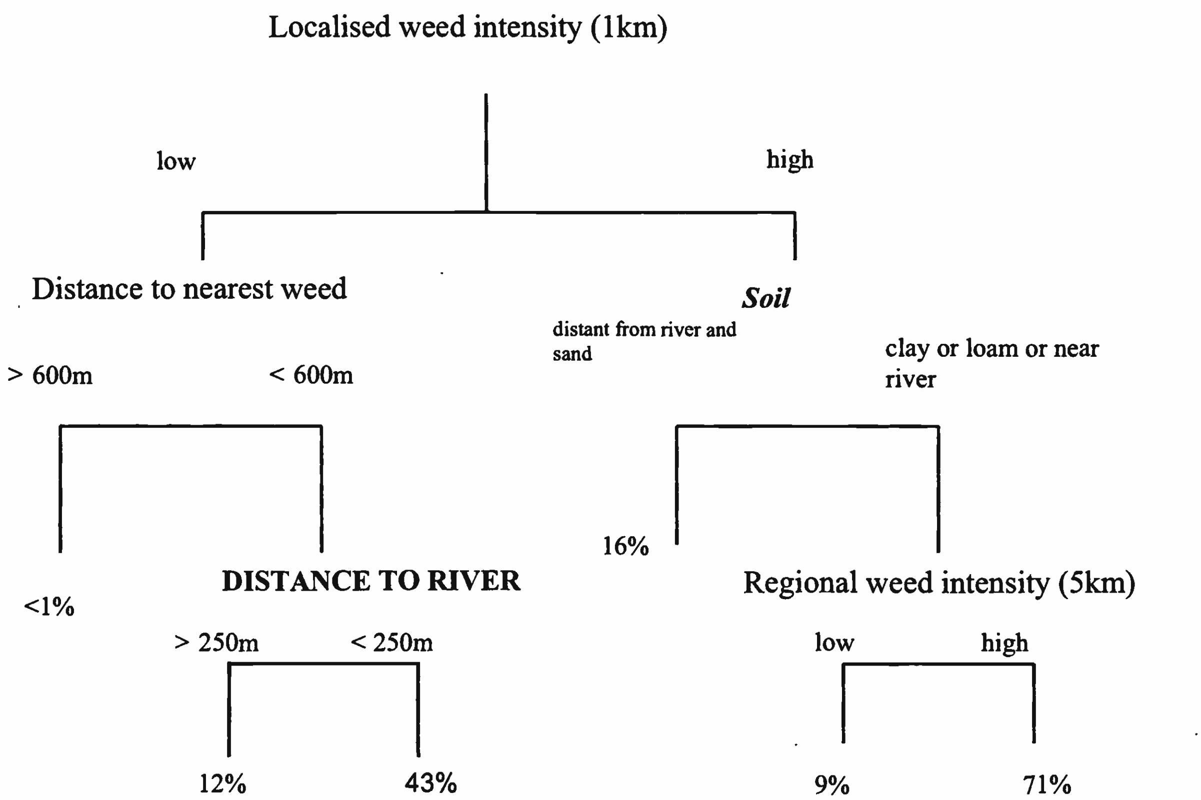


Figure 1. A regression and classification tree that describes the distribution of *Parkinsonia aculeata* in the Cape River Catchment of North Queensland.

CONCLUSION

A regression and classification tree has been used to evaluate the distribution of *P. aculeata* in the Cape River catchment of North Queensland. This methodology enabled habitat and spatial characteristics to be combined. It suggests the invasion process is localised, but if left unmanaged *P. aculeata* would eventually occupy most of the riparian zone.

REFERENCES

Lawes, R.A., Whiteman, L.V. and Grice, A.C. (2003). Mapping the distribution of *Parkinsonia aculeata* in the Cape River catchment in north Queensland, Australia. *Plant Protection Quarterly* 18: 152-156.

RE-DEFINING CARRYING CAPACITIES IN THE ASHBURTON RIVER CATCHMENT IN WESTERN AUSTRALIA

K.A. Leighton [1] *and A.M.E. Van Vreeswyk* [2]

[1] Department of Land Information, PO Box 2222, Midland, WA, 6936
[2] Department of Agriculture, Locked Bag No. 4, Bentley Delivery Centre, WA, 6983

INTRODUCTION

A joint rangeland survey team from the Department of Agriculture and the Department of Land Information has the responsibility for determining carrying capacities for the pastoral areas of Western Australia. Potential carrying capacities for land systems in the Ashburton River catchment of Western Australia were first estimated from data collected during the rangeland survey of the area in 1978 (Payne *et al.* 1988). These figures suggested a sustainable level of total grazing pressure assuming that all pastures were in good range condition, the entire pastoral lease was adequately watered for the management of stock, and seasonal conditions were average.

THE PARADOX OF BUFFEL GRASS

Since the time of the survey buffel grass (*Cenchrus ciliaris*), and to a lesser extent Birdwood grass (*C. setigerus*), has established widely throughout the catchment. Buffel is a perennial exotic grass widely regarded in the Western Australian pastoral industry as a very useful feed source for livestock. It is highly palatable when green and relatively resistant to grazing. It colonises readily on alluvial plains, especially on areas that have been overgrazed or disturbed. However, it is considered a pernicious weed by conservationists because it is known to reduce biodiversity as it can form a monoculture to the exclusion of native grasses. A paradox exists in its classification as both a valuable pasture plant and a significant environmental weed.

RE-ASSESSMENT OF CARRYING CAPACITY

In April 2001 and April 2002 the rangeland survey team re-inspected parts of the original survey area to determine the spread of buffel. One of the team members was present during the original survey and recalled visiting the sites thirty years previously. The survey team found that buffel grass had spread extensively since the early survey (Payne *et al.* 2004). In some cases, areas that were mapped as severely degraded and eroded in the 1970's had recovered well with buffel and other native grasses such as Roebourne Plains grass (*Eragrostis xerophila*). However other, more saline, areas had not responded, even with regeneration treatment.

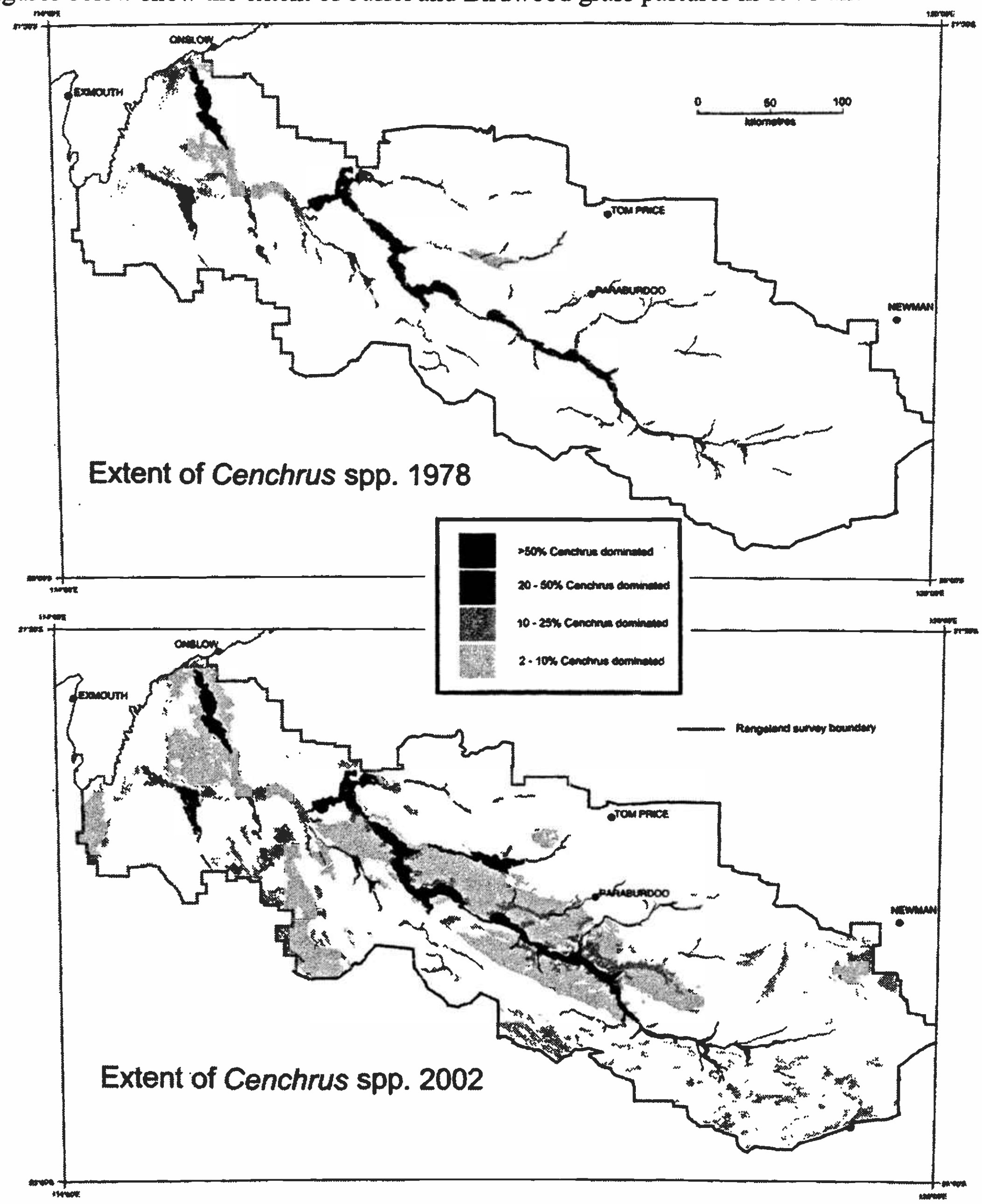
The widespread establishment of buffel grass has significantly increased the carrying capacity of the area. Buffel grass pastures are more productive than native pastures; buffel grass pastures in the Ashburton survey area were rated at nine hectares per cattle unit (ha/cu) while native tussock grasslands were rated at 15 ha/cu and shrublands at more than 55 ha/cu.

On one river frontage land system the proportion that is dominated by buffel grass increased from 5% in 1978 to 64% in 2002. In the hill systems where the spread of buffel is restricted to drainage lines a typical increase was from 0 to about 5%.

> ... Bulloo Downs wouldn't be worth a kick in the pants only for the buffel grass - buffel grass saved Bulloo Downs, the more of it the better ...
> **Peter Hall, Bulloo Downs Station, April 2002**

Based on the re-assessment and consultation with pastoralists a potential carrying capacity was calculated for each station in the survey area. This resulted in the potential carrying capacity of Ashburton stations being increased by an average of about 60%. For stations with extensive Ashburton River frontage the increase was up to 150%.

The figures below show the extent of buffel and Birdwood grass pastures in 1978 and 2002.



REFERENCES

Payne, A.L. Mitchell, A.A. and Holman, W.F. (1988). *An inventory and condition survey of rangelands in the Ashburton River catchment, Western Australia.* Western Australian Department of Agriculture Technical Bulletin No. 62 (Revised edition).

Payne, A.L., Van Vreeswyk, A.M.E. and Leighton, K.A. (2004). *Re-assessment of carrying capacities in the Ashburton River catchment.* Department of Agriculture, Western Australia Miscellaneous Publication 16/2003 (Revised edition).

USING THE SAVANNA.AU MODEL TO UNDERSTAND THE FUNCTIONING OF AUSTRALIA'S NORTHERN RANGELANDS

Adam C. Liedloff[1] *and John A. Ludwig*[2]

[1] Tropical Savannas Management CRC, CSIRO Sustainable Ecosystems, PMB 44, Winnellie NT 0821
[b] Tropical Savannas Management CRC, CSIRO Sustainable Ecosystems, Maunds Road, Atherton Qld 4883

INTRODUCTION

Computer simulation modelling provides a valuable means of understanding the functioning of Australia's rangelands and predicting the outcomes of various management strategies. Models are particularly useful when outcomes need to be determined over extended periods of time which exclude the use of field measurements (eg. simulating the effect of changing fire regimes on trees), or when hypotheses need to be tested under conditions that are not currently realised such as increases in temperatures as a result of global warming. They are also useful to test the outcome of management practices that would incur economic costs to test by field trials such as the effect of changes in stocking rates.

Ecological models are developed based on currently known relationships relating to the functioning of a system. All key processes are incorporated into the model code and the model runs on a given time-step performing all calculations and keeping track of values over time. All models are a trade-off between mechanistic detail and model simplicity. Highly mechanistic models can be notoriously difficult to implement and parameterise and often require expert assistance to use. They can also be computationally demanding which limits the spatial and temporal extent that can be modelled. These models do however provide a very detailed understanding of the processes occurring and become excellent research tools. On the other hand, aggregated or simplified models are easy to use, but less realistic, less generalisable and less able to explain the reasons for particular model outcomes.

THE SAVANNA.AU MODEL

The Savanna model was developed to study a 10,000 sq km nomadic pastoral ecosystem in arid east Africa by Mike Coughenour (Colorado State University, USA). It can be considered as intermediate on the continuum of model complexity running on a weekly time step and allowing for large areas to be simulated. Savanna is a spatially explicit, process-orientated model designed to simulate savanna ecosystems exposed to grazing and fire.

Savanna.au is a version developed specifically for Australia's tropical and sub-tropical savannas using modern programming languages and concepts. This version incorporates a number of additional aspects considered important in simulating Australian systems. While some processes are modelled on a weekly or monthly time-step, highly dynamic processes such as soil water and infiltration are modelled on a daily time-step. The ever increasing power of computers means the average personal computer is quite capable of handling the level of complexity built into the model over annual to decadal time scales. The model has also been designed to use the minimal number of variables possible to capture the important processes and use parameters that can be obtained by ecologists and land managers in the field or from published literature.

By default, Savanna.au is set up to simulate a hectare cell and is capable of modelling a group of cells representing a paddock, hillslope or catchment. Interactions between cells are considered which accounts for movement of water between cells based on overland flow and the movement of seeds.

Savanna.au also includes a user interface to facilitate data entry, parameter checking, running the model and graphing and exporting results.

MODEL COMPONENTS

The components of any model determine what questions can be asked and what situations can be simulated. The Savanna.au model includes a comprehensive range of processes operating in the savannas which include:

- Eco-hydrology (soil water, infiltration, run-off, macropore development, topography).
- Soils (depth and textural properties, water and nutrients).
- Plant processes (photosynthesis, assimilation, phenology, transpiration, CO_2 exchange, seeding, mortality).
- Nitrogen cycling.
- Litter (decomposition).
- Climate (rainfall, temperature, radiation, CO_2 levels).
- Grazing (species preferences, spatial grazing effects, distance to water, offtake).
- Fire (weather conditions, fuel dynamics, plant mortality).

CURRENT AND FUTURE APPLICATIONS

While development of the model continues, Savanna.au is currently being tested and validated using a number of case studies. Plant growth and pasture production are being simulated for the Victoria River Research Station (Kidman Springs, NT). Nutrient cycling and plant competition are being tested with studies of invasive grassy weeds in the Top End (Darwin, NT). Infiltration and hillslope runoff are being simulated at Virginia Park (Charters Towers, Qld). Future developments and studies will investigate preferential grazing, the effect of water points on grazing distributions and the effects of fire on trees and grasses.

FROM DEVELOPMENT TO INNOVATION: THE NORTHERN MLA EDGE*NETWORK* GRAZING LAND MANAGEMENT WORKSHOP

B.S. McCallum, C.J. Paton, B. Schulke, R.N. Shepherd, W.E. Holmes, M. McCullough & M.F. Quirk*

*DPI&F, PO Box 976, Charters Towers, Qld 4820

INTRODUCTION

Beef producers of the Burdekin rangelands, the speargrass country of the Burnett region, the Mitchell grass country of Western Queensland, and the Victoria River District of the Northern Territory now have access to a comprehensive suite of practical education tools designed to assist them in gaining knowledge and developing skills to improve their livestock enterprises. The Northern MLA EDGE*network* Grazing Land Management workshop (Chilcott *et al.*, 2003) is the product of the Grazing Land Management Education Program (Quirk *et al.*, 2001) supported by Meat and Livestock Australia.

The Grazing Land Management (GLM) Education program was born out of a belief that the industry could be getting greater benefit from the information and outputs of past research and development programs, particularly those with an ecological approach to grazing land management. The project represented a first in terms of bringing a wide range of grazing land management information together in a way that is aimed at stimulating decision-making, planning and adoption.

The GLM Workshop is a joint effort, involving a 15-strong development team, representing the Department of Primary Industries and Fisheries, CSIRO, Department of Natural Resources and Mines, Tropical Savannas CRC and the Northern Territory Department of Primary Industries and Fisheries. Substantial funding support has come from Meat and Livestock Australia.

WORKSHOP CONTENT

The GLM workshop was developed after extensive consultation with the grazing industry and represents a range of practical workshop sessions and learning opportunities tailored to the needs of producers in their region. Each regional package uses the best available local research and development findings, ensuring that the information given to producers is entirely relevant to their situation. A case study property complete with land types and grazing land management problems typical of the region enables participants to practice theories in a real life situation before applying the principles to their own property.

Grazing Land Management EDGE assists producers in:

- Understanding the relationships between water, soils, plants, biodiversity, fire and weeds;
- Understanding and managing climate variability;
- Managing grazing;
- Maintaining both native and sown pasture systems;
- Meeting target markets while maintaining sustainability and,
- Determining the financial implications of grazing management options.

There are seven workshop modules. Producers develop their own grazing management plan during the final session. The workshop provides a framework for assessing a property's land condition and the potential for improvements in both land condition and productivity.

The workshop requires a commitment of five days spread over six months. There is an information and preparation session, followed by an intensive three-day workshop and a follow-up day on property. The workshop uses an interactive style, building on participant's knowledge. To suit local requirements each workshop is flexible in the allocation of time devoted to specific subjects. Workshops are organised for groups of 10-15 participants based on location and date availability.

WORKSHOP EVALUATION

The GLM Workshop has been delivered by Queensland DPI&F and DBIRD officers in the Burdekin, Burnett and Victoria River District and will soon be available for the Mitchell grass country of Western Queensland. The participants critically evaluate each workshop. Participants Feedback sheets provide a rating of each module using a one to five scoring system; where one is 'of no use at all' and five is 'extremely useful'. Participants are also asked to rate their knowledge of the subject before the workshop, and record comments on information they would like to see included, or left out of the module. At the end of the workshop participants are then asked to rate the workshop presentation, give overall comments, and consider how the workshop will alter their grazing land management.

The evaluations have shown that participants have really enjoyed and taken on the principles of the workshop. Enjoyment levels have been high because the workshop focuses on strategies to increase profit and sustainability. DPI&F officers believe the workshops have been very successful and significant changes in participants' knowledge and learning about the principles of GLM have occurred. Officers have also received extremely positive feedback from participants. The average score for workshop presentation is 4.6 out of 5. The workshop continues to draw interest from graziers in these regions, principally by word-of-mouth, which is a positive sign of the workshop's success.

The participants' level of knowledge has varied from those seeing grazing management concepts for the first time, to those who competently run intensive grazing systems. Workshop flexibility has allowed presenters to cater for groups that have a range of knowledge and skills. Not only have participants with basic prior knowledge benefited from the workshop, but evaluation has also shown that participants that manage intensive grazing systems have gained new skills, new knowledge and reinforced their beliefs in key grazing management principles.

The evaluation system has also lead to continuing improvements of the package. Feedback from participants has been incorporated for subsequent workshops and has thus contributed to a smooth running and relevant workshop.

WORKSHOP EXPANSION

The Grazing Land Management Education Program and the Northern MLA EDGE*network* Grazing Land Management Workshop has proven to be a sought after product. Customising the workshop to the Murray-Darling Basin, southwest Queensland Mulga, Coastal Burnett and Mary Regions, Fitzroy Basin, north Queensland Gulf, and central Australia (Alice Springs) will begin shortly. There are also plans to extend the program to the Desert Uplands, Lake Eyre Basin (Desert Channels) and Southern Gulf regions of Queensland.

REFERENCES

Quirk, M.F., Oxley, T.J., and Blakeley, S. (2001). Developing an education program in grazing land management for livestock producers in northern Australia. North Australia Beef Industry Conference Proceedings, Kununurra, Western Australia.

Chilcott, C.R., McCallum, B.S., Quirk, M.F. and Paton, C.J., (2003). Grazing Land Management Education Package Workshop Notes – Burdekin. Meat and Livestock Australia Limited, Sydney.

Chilcott, C.R., Paton, C.J., Quirk, M.F. and McCallum B.S. (2003). Grazing Land Management Education Package Workshop Notes – Burnett. Meat and Livestock Australia Limited, Sydney.

Chilcott, C.R., Oxley, T.J., Dyer R.M. and MacDonald, R.N. (2004). Grazing Land Management Education Package Workshop Notes – Katherine. Meat and Livestock Australia Limited, Sydney.

QUANTIFYING THE BENEFITS OF SUSTAINABLE MANAGEMENT IN A VARIABLE CLIMATE: RESULTS FROM THE WAMBIANA GRAZING TRIAL

Peter O'Reagain, John Bushell & Chris Holloway

QDPI&F, PO Box 976, Charters Towers, 4820.

INTRODUCTION

Current recommended strategies to cope with climate variability are not widely adopted, due partly to the perception that sustainable strategies are uneconomic. In this paper we provide preliminary data from a long-term study suggesting that sustainable strategies, such as light stocking, deliver significant benefits to both resource condition and the economic performance of grazing enterprises.

METHODOLOGY

The trial was established in 1997 on Wambiana station, near Charters Towers (MAR= 650 mm, C.V.=40%) to test the ability of different grazing strategies to cope with rainfall variability (O'Reagain and Bushell 2003). Ten *c.*100 ha paddocks were established in an open Eucalypt/Acacia savanna on soils of relatively low fertility. Paddocks contain similar areas of yellow earth, texture contrast and black cracking clay soils. Strategies being tested are (i) constant *light stocking*, run at 8ha per large stock unit (LSU), (ii) constant *heavy stocking* (4 ha/LSU), (iii) *variable stocking* - stock numbers adjusted annually in May according to available forage (range: 3-10 ha/LSU), (iv) a *variable-SOI* (Southern Oscillation Index) strategy – stock numbers adjusted annually in November according to available forage and SOI-based climate forecasts (range: 3-10 ha/LSU) and (v) *rotational spelling* (6 ha/LSU) – 1/3 of the pasture spelled annually during the wet season. Treatments are replicated twice. Paddocks are stocked with Brahman-X steers of *c.* 2.5 years of age. Dry season urea supplementation is provided to all treatments. Animals are weighed six weekly and pasture composition monitored annually using BOTANAL (Tothill *et al.* 1992).

RESULTS AND DISCUSSION

Rainfall was above average over the first four years of the trial but declined sharply thereafter with the last three seasons being in the lowest 20% of rainfall years. In all years, individual animal production was consistently higher (30-50kg/head) under light than in the heavier stocked treatments. This difference may be attributed to the lower diet quality and reduced pasture availability confronted by animals under heavy stocking (O'Reagain and Bushell 2003). In contrast to individual animal production, total animal production/ha was markedly higher under heavy than under the lighter stocking regimes. However, the magnitude of this difference declined sharply with time due to reduced rainfall and the cumulative effects of heavy stocking on pasture production and composition. For example, while animal production/ha was 71% greater under heavy than under light stocking in 1998/1999, this difference was only 16% in 2002/2003.

Importantly, in this last season animals in the heavy stocking rate treatment required feeding with molasses and urea (M8U) to prevent mortality, incurring a significant cost to production. Preliminary economic analysis thus indicates that in 2003/2004 gross profit/ha was only marginally lower under light than under heavy stocking, despite running half the number of cattle as the latter treatment (Table 1). The economic advantages of lighter stocking are likely to be amplified at the enterprise level due to the effects of reduced time to turnoff on overall herd efficiency and the improved marketing opportunities for better condition cattle.

After six years, marked differences are also obvious between treatments in terms of both pasture yield and composition (Fig. 1). Overall, the contribution of 3-P (palatable, productive and perennial) grasses to yield is far greater, while the *proportion* of wire grasses is lower, under light stocking, than in any of the other strategies.

Table 1. Urea consumption, beef production and gross profit per hectare from five different grazing strategies over the 2003-2004 grazing season.

Stocking Strategy	Urea consumption (kg/ha)	Supplement cost ($/ha) [1]	Production per ha (kg/ha)	Production value ($/ha) [3]	Profit per ha ($/ha)
Variable	1.51	0.69	12.77	19.15	18.46
R/Spell	2.00	0.91	9.40	14.09	13.18
SOI	1.40	0.64	11.60	17.40	16.76
Heavy	2.93	8.97 [2]	24.31	36.46	27.49
Light	2.04	0.93	17.34	26.01	25.08

[1] Urea costed at 0.45c/kg [2] Includes cost of molasses and urea [3] Beef valued at $1.50/kg

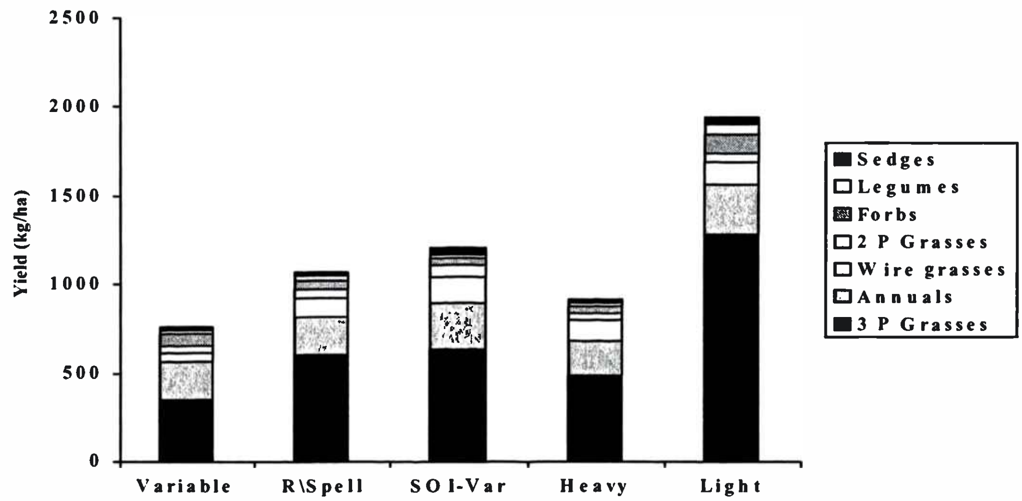


Figure 1. Contribution to yield in May 2003 of different species groups under five stocking strategies at the Wambiana grazing trial.

The present results suggest that sustainable strategies like light stocking not only maintain resource condition in a variable climate but also deliver strong economic benefits likely to enhance enterprise viability. However, the present work needs to be continued before a definitive analysis of the relative performance of all strategies will be possible.

ACKNOWLEDGEMENTS

We are grateful to the Lyons family of Wambiana for their continuing support of the grazing trial. The present work is funded by Meat and Livestock Australia.

REFERENCES

O'Reagain, P.J. and Bushell, J.J (2003). Effect of grazing strategy on animal production in a seasonably variable tropical savanna. *Proc. VIIth Int. Range. Cong., South Africa,* July 2003, 913-915.

Tothill, J.C., Hargreaves, J.N.G, Jones, R.M and McDonald, C.K. (1992). BOTANAL – a comprehensive sampling and computing procedure for estimating pasture yield and composition 1. Field sampling. CSIRO Trop. Agron. Memo. #78.

LONG TERM RESPONSES OF *Astrebla spp.* (MITCHELL GRASS) TUSSOCKS TO RAINFALL IN NORTH-WESTERN QUEENSLAND

D.M. Orr [1] *and D.G. Phelps* [2]

[1] Dept. Primary Industries & Fisheries, PO Box 6014, Rockhampton Qld 4702
[2] Dept. Primary Industries & Fisheries, PO Box 519, Longreach Qld 4730

INTRODUCTION

Drought is an ever-present problem for sustainable grazing enterprises in the semi-arid and arid zones of Australia. Little is known of the long-term responses of pastures to drought although some studies, such as that in *Astrebla* spp. (Mitchell grass) grasslands (Everest 1935), have documented a poor short-term response by perennial grasses to severe drought. Despite this, *Astrebla* grasslands are considered to be resilient to moderate grazing during "average" to above average rainfall (Orr 1998). This paper presents data on changes in plant size and survival of *Astrebla* spp. for both the original plants and for three selected cohorts in relation to rainfall between 1984 and 2003 in a grazing study in north-western Queensland. In particular, we report the impacts of the 1987-89 and 2001-03 droughts.

METHODS

An unreplicated grazing study incorporating six levels of annual utilization (0, 10, 20, 30, 50 and 80% of end of summer forage) by sheep commenced in *Astrebla* grassland at "Toorak" Research Station, northwest Queensland in 1984 and remains current in 2004 (Orr and Phelps 2003). Population dynamics of *Astrebla* spp. are monitored annually by charting the position and diameter of the initial tussocks and newly recruited seedlings in permanent quadrats, each 1 x 1 metre, in the 10, 30, 50 and 80% utilisation paddocks.

Individual plant size is determined as the area covered by each plant and is calculated by dividing the basal area per quadrat by the number of individual plants (incorporating the number of segments of these plants) of the different age plants in that quadrat. We demonstrate the impact of the 1987-89 and 2001-03 droughts by presenting data for the initial, mixed age (1984) plants and for plants recruited during the 1986-87, 1988-89 and 1993-94 summers. For the purpose of this paper, we have pooled data for each cohort across the four utilisation treatments.

RESULTS

The mean size of the original *Astrebla* spp. plants at the start of this study in 1984 was 350 sq cm but had declined substantially to be <10 sq cm by 1990 (Figure 1a) due to the 1987-89 drought. This reduction in plant size was associated with a similar reduction in tussock survival (Figure 1c) and there was a clear trend for this decline in tussock survival to be greatest at 80% utilisation (data not presented). After 1990, surviving original tussocks increased in size to be 100 sq cm in 2000 however, the 2001-03 drought again caused a substantial decrease to an overall size of <10 sq cm in 2003. There was evidence of a further small decline in tussock survival between 2001 and 2003.

Seedling recruitment of 1.5, 32.0 and 0.6 seedlings/sq m were recorded in 1987, 1989 and 1994 respectively. Tussocks arising from each of these recruitment events continued to increase in size with increasing age until the severe 2001-03 drought caused a substantial decline in tussock size irrespective of age (Figure 1b). Despite this substantial decline in tussock size, there was some decline in survival for the 1994 cohort but not for either the 1987 or 1989 cohorts (Figure 1d).

DISCUSSION

Our results clearly indicate that drought has impacted on *Astrebla* spp. by substantially reducing plant size for all ages. Despite this, some plants from each cohort persisted throughout the drought. This ability to persist through drought is consistent with documented long life spans of 23 years for individual *Astrebla* spp. plants (Williams and Roe 1975).

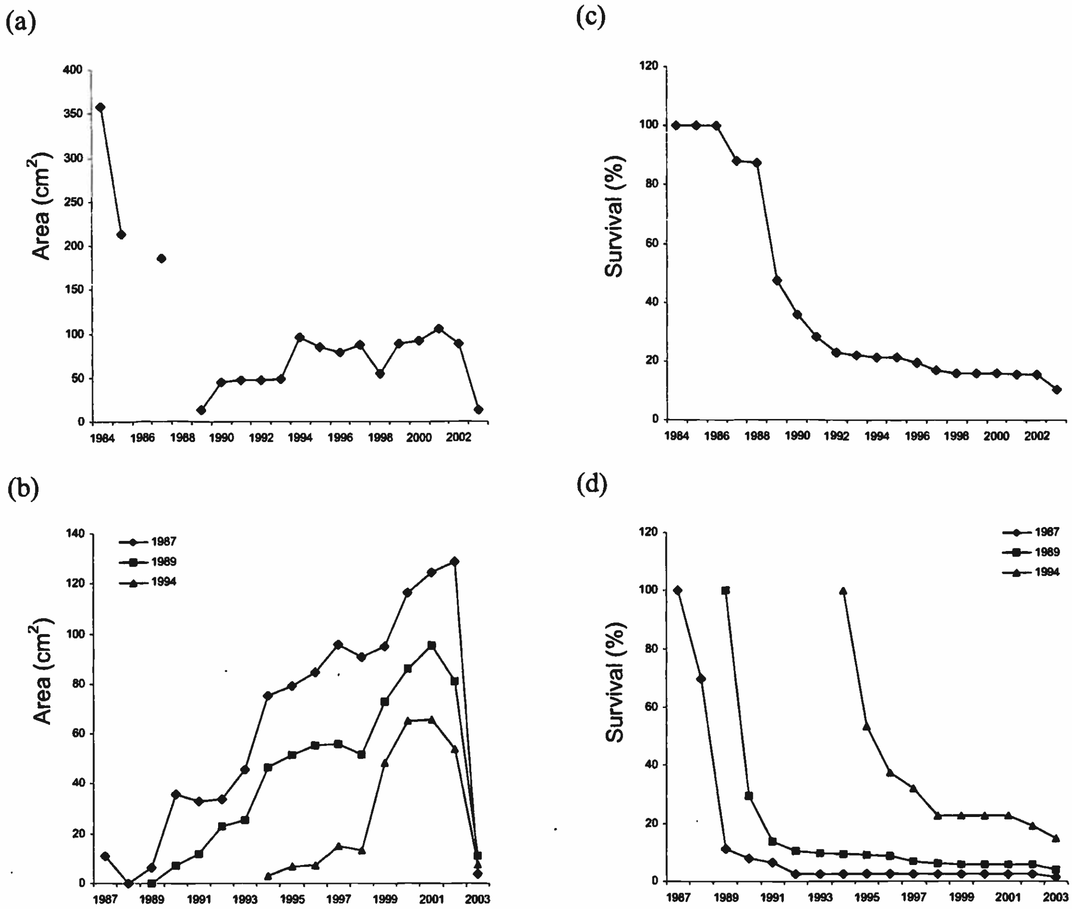


Figure 1. Changes in the size (sq cm) of *Astrebla* spp. tussocks of (a) Original plants, (b) 1987, 1989 and 1994 cohorts and of plant survival (%) of (c) Original plants and (d) 1987, 1989 and 1994 cohorts.

Our results indicate that only small reductions in the survival of *Astrebla* spp. during the 2001-03 drought at Julia Creek conflict with reports of extensive death of *Astrebla* spp. in central western Queensland (J. Milson, *pers. comm.*). These differences possibly reflect a greater severity of drought in the central west compared with our northern site and this may be manifest in higher plant death.

The Toorak grazing study will continue to measure the impact of rainfall and grazing pressure. The continuation of this grazing study will be achieved through new financial support provided by BHP Billiton through their Cannington Mine at nearby McKinlay.

REFERENCES

Everest, S.L. (1935). Responses during 1934 season of Mitchell and other grasses in Western and Central Queensland. *Qld. Agric. J.* 43: 374-387.

Williams, O.B. and Roe, R. (1975). Management of arid grasslands for sheep: plant demography of six grasses in relation to climate and grazing. *Proc. Ecol. Soc. Aust.* 9: 142-156.

Orr, D.M. (1998). A life cycle approach to the population ecology of two tropical grasses in Queensland. *In* "Population biology of grasses", Ed. G. Cheplick, Cambridge University Press, pp. 366-89.

Orr, D.M. and Phelps, D.G. (2003). Plant species diversity in *Astrebla* spp. grassland following 18 years of sheep grazing. *Proc. VII th Int. Rangel. Cong., Durban*, pp. 256-258.

BLACK SPEARGRASS *(Heteropogon contortus)* PERSISTENCE VARIES ACROSS ITS GEOGRAPHIC RANGE

D.M. Orr [1], *T.J. Hall* [2] *and P.A. Jones* [3]

Dept. Primary Industries & Fisheries: [1] PO Box 6014, Rockhampton Qld 4702
[2] PO Box 308, Roma Qld 4455, [3] Locked Mail Bag 6, Emerald Qld 4720

INTRODUCTION

Heteropogon contortus (black speargrass) dominant pastures occupy 25 M ha and occur on a wide variety of soil types which receive between 700 and 1200 mm annual rainfall. They are an important forage resource for the breeding and finishing of 3-4 million beef cattle in Queensland. Diet selection studies using oesophageal fistulated steers (R.E.Hendricksen, unpublished data) indicate that steers selectively graze H. contortus throughout the year and that it is selected in preference to almost all other grass species.

Because of the importance of this species to Queensland's beef cattle industry, a knowledge of its persistence is useful in developing sustainable grazing practices. This paper compares the demographic performance of H. contortus at four sites across regional Queensland.

METHODS

Extensive grazing studies have been conducted at Galloway Plains, Calliope, central Queensland (Orr *et al.* 2001), at "Glenwood", Mundubbera, southern Queensland (Orr *et al.* 2004) "Keilambete", central highlands of Queensland (Jones *et al.* 2001) and at "Wambiana", Charters Towers (O'Reagain and Bushell 1999). Permanently located quadrats, either 50 x 50 cm or 100 x 100 cm, were established at each grazing study to examine the persistence of *H. contortus* in relation to grazing management options – mainly stocking rates. In each of the quadrats, the position of each *H. contortus* plant was charted from the commencement of each study with subsequent recordings made annually. Further details of this methodology are reported in Orr *et al.* (2004). Data presented here include the survival of the original plants and one annual seedling cohort of *H. contortus* plants from each grazing study.

RESULTS

The survival of *H. contortus* plants, both original plants and annual seedling cohort, at all four grazing studies displayed a similar pattern of high initial mortality of plants (Figure 1). There was a clear trend for both initial plants and the annual seedling cohorts at "Glenwood", "Galloway Plains" and "Keilambete" to have extended life spans. However, both the original plants and the 2000 seedling cohort at "Wambiana" displayed continuing mortality as distinct from the extended survival as displayed by plants at the other three more southerly grazing studies.

DISCUSSION

These data indicate clear differences in the survival of *H. contortus* at the four sites with plants in northern Queensland being less persistent than those in central and southern Queensland.

One possible reason for these differences in survival is the severity of the dry season at "Wambiana". All four sites have a predominantly summer rainfall, however, the dry season at "Wambiana" is longer and more severe than at the southern sites where firstly, the dry season is less pronounced and secondly, annual rainfall is more evenly distributed throughout the year. These two considerations suggest that conditions for plant growth at "Wambiana" are less favourable than at the other three sites.

T. J. Hall (unpublished data) compared four ecotypes of *H. contortus* from across northern Australia (Katherine, Mareeba, Torrens Creek and Mundubbera) both at home and at the three other locations. Results indicate that the southern ecotypes are faster at producing tillers, faster at developing inflorescences and shed seed earlier than the more northern ecotypes. Furthermore, although southern ecotypes don't grow as tall, these southern ecotypes produce more total tillers and can respond to better growing conditions as indicated by higher plant yields in the second year of growth compared with northern ecotypes. It is probable that these characteristics confer better plant survival.

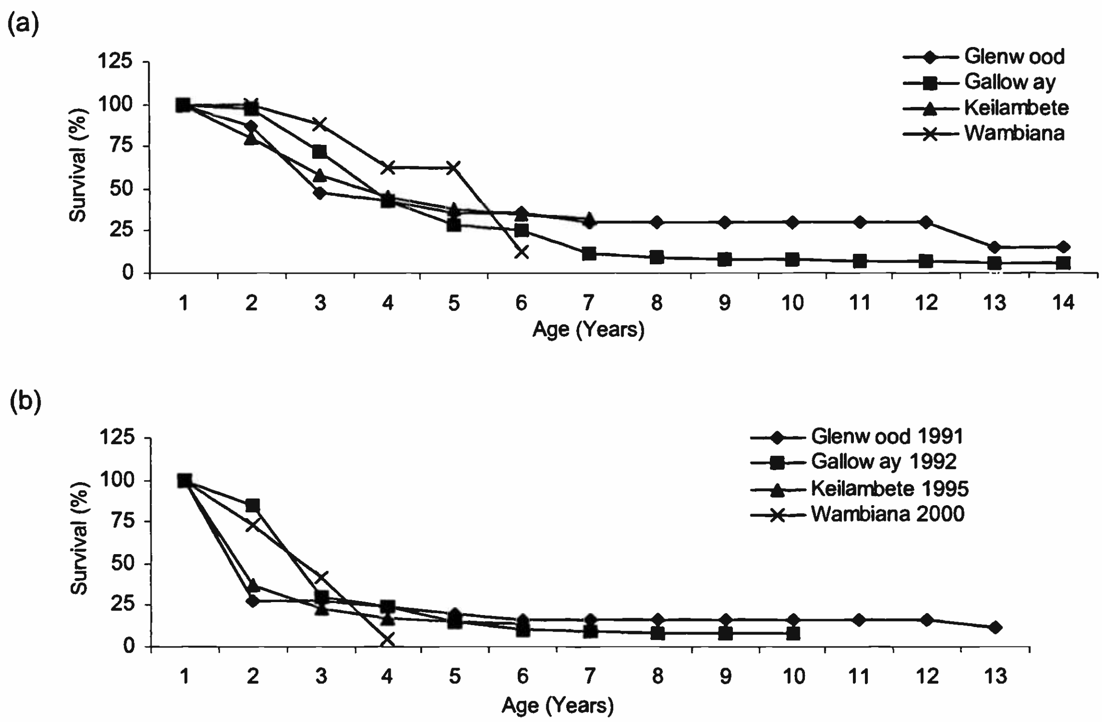


Figure 1. Survival (%) of (a) original plants and (b) one annual seedling cohort of *Heteropogon contortus* at four sites across Queensland.

Under grazing in northern Queensland, *H. contortus* plants were almost eliminated after five years grazing at stocking rates of 0.95 and 1.25 beasts/ha but continued to contribute 5-10% of total pasture yield (Jones 2003). In contrast, *H. contortus* persisted for 13 years at a stocking rate of 0.5 steers/ha in central Queensland where it contributed 30% of total pasture yield (Orr *et al.* 2001). These data indicate that the persistence of *H. contortus* varies across its geographic range and this fact needs to be considered when devising sustainable grazing management practices.

REFERENCES

Jones, P.A., Sullivan, A., Silcock, R.G. and. Waters, D. (2001). The *A-B*, a fragile yet resilient native pasture community. Proceedings "Remnant vegetation in the Brigalow Belt" Symposium.

Jones, R.J. (2003). Effects of sown grasses and stocking rates on pasture and animal production from legume-based pastures in the seasonally dry tropics. *Trop. Grassl.* **37**, 129-150.

O'Reagain, P.J and Bushell, J.J. (1999). Testing grazing strategies for the seasonally variable tropical savannas. Proc. VI th Int. Rangel. Cong., 485-486.

Orr, D.M., Burrows, W.H., Hendricksen, R.E., Rutherford, M.T., Conway, M.J., Myles, D.J., Back, P.V., and Paton, C.J. (2001). Pasture yield and compositional changes in a central Queensland black speargrass (*Heteropogon contortus*) pasture in relation to grazing management options. *Aust. J. Exp. Agric.* **41**, 477-485.

Orr, D.M., Paton, C.J. and Reid, D.J. (2004). Dynamics of plant populations in *Heteropogon contortus* (black speargrass) pastures on a granite landscape in southern Queensland. 1. Dynamics of *H. contortus* populations. *Trop. Grassl.* **38**, 17-30.

EDGE NETWORK – GRAZING LAND MANAGEMENT

T.J. Oxley and R.N. Mather-Brown

DBIRD, PO Box 1346, Katherine, NT 0851

INTRODUCTION

EDGEnetwork is the education arm of Meat and Livestock Australia (MLA). EDGE currently provides a number of courses and workshops for people in the pastoral industry. EDGE now provide courses applicable to northern pastoralists, with the Grazing Land Management (GLM) course further specialised to suit local regional areas. Packages have been developed in four regions, Katherine, Burdekin, Burnett and Queensland Mitchell Grass.

GLM consists of seven modules that have been developed to build on the participant's knowledge of maintaining natural resource sustainability while improving business profitability. GLM provides tools and knowledge to consider both the economic and environmental effects of grazing management options.

COURSE BACKGROUND

After a range of separate government agencies (QDPI and DPIF), funding bodies (MLA) and Tropical Savannas CRC identified the need for collating current research about grazing management knowledge, the development of the GLM package began in 1999. It was believed this needed to be undertaken in a manner that would produce better extension and education material for producers and industry support staff throughout northern Australia.

At the same time it was separately identified by producers they required better information about grazing management.

All identified it was important that information was region specific and would be delivered by local experts. The course has been developed to ensure that research data were combined and presented in a way that allowed pastoralists to both learn theory and be able to apply it in practical ways.

COURSE CONTENT

GLM course topics were developed as a result of a major survey of northern Australia producers. Their main interest areas then provided the module subjects which are as follows:

- Understanding the Grazing System.
- Managing Grazing.
- Managing Fire.
- Understanding Tree-Grass Balance.
- Managing Sown Pastures.
- Managing Weeds.
- Planning for Grazing Management.

Key topic areas within these modules include how to maintain and improve land condition, managing pasture species composition, calculating carrying capacities and understanding different land types.

The regional approach has meant there is flexibility to focus more closely on topic areas in certain regions, for example, the fire module of the Katherine version is much more extensive than it is for the Burnett version.

The course has an informal style that is based around activities and discussion to promote information sharing between producers and encourage learning through participation and practise. There is a strong focus on providing practical tools that producers can use in their grazing management planning when they return home.

Undertaking the planning module helps relate the theory learned to how producers are going to apply their ideas to their home property. It is designed so they complete the course with the beginnings of their property grazing management plan.

WHAT HAS HAPPENED SO FAR?

The first Katherine workshop was held in March and producers gave very positive feedback as to the usefulness of the course to their grazing management. Other regions have received similar feedback.

There are now another four regions in Queensland and the NT who have started to develop their own region specific course. It would be expected that as the courses become available in more areas the content of the GLM course will continue to evolve in conjunction with improved land management practises and new grazing management research.

EVALUATING GRAZIER KNOWLEDGE OF SEASONAL CLIMATE FORECASTING IN THE MITCHELL GRASSLANDS OF WESTERN QUEENSLAND

Janelle N. Park [1], *David H. Cobon* [2] *and Kerry L. Bell* [2]

[1] Queensland Department of Primary Industries & Fisheries, PO Box 519, Longreach Q 4730
[2] Queensland Department of Primary Industries & Fisheries, PO Box 102, Toowoomba Q 4730

ABSTRACT

Similar surveys were conducted in western Queensland in 2000 and 2003 to compare graziers' knowledge and use of climate information and seasonal climate forecasting. There was a decline in knowledge of using self-rating questions and an increase in knowledge using test questions. Graziers preferred to access their climate information via the Internet, email and targeted newsletters.

INTRODUCTION

In 2000, as part of a Natural Heritage Trust project entitled "Sustainable grazing – balancing resources and profit in western Queensland", a survey of graziers in the Mitchell grasslands of western Queensland benchmarked graziers' understanding of the use of climate information in relation to grazing management decisions. The results of this survey also helped to make important changes in project planning, activities and methods of transferring technology, tailored to grazier preferences (Keogh *et al.* 2003). A similar survey was conducted at the start of 2003. The results from this survey enabled a comparison of graziers' knowledge and use of climate information over the duration of the three-year project. This paper presents the comparison between the two surveys to determine the change in use, knowledge and attitude in relation to seasonal climate forecasting and other climatic phenomena.

MATERIALS AND METHODS

The first survey in November 2000 involved 100 randomly selected graziers in seven shires of western Queensland. Both mail and phone techniques were used with a 43% response rate (Keogh *et al.* 2004). In March 2003 a similar survey was conducted by mail and all respondents of the first survey were asked to complete the second, and of the remaining graziers, about 13% were randomly selected from each shire. One hundred and forty one graziers were selected with 49 responses being received (35% response rate).

Self-rating (scale of 1 to 10) and test question (multiple choice) techniques were used in both surveys to determine knowledge and use of climate systems. In addition graziers were asked questions to determine their preferred information sources and use of electronic media. Chi-square tests were used to test for independence of counts and t-tests were used to compare ratings on a scale of one to ten. A significance level of 5% was used.

RESULTS

In the self rating questions knowledge of a range of climate phenomena declined in all areas over the three years. Response rates of "Sources of weather and climate information" were highest while "Probability of exceedance" was rated the lowest.

In the test question section there were three questions identical in both surveys. Results showed improved knowledge in the second survey compared to the first. The question "The Southern Oscillation Index in an El Niño year is?" was the only question that showed statistical significance with the percentage of correct answers increasing from 68% in 2000 to 89% in 2003. The question "In western Queensland, ENSO has the largest impact on?" showed that while the number of correct answers increased from 11% to 33%, many graziers are still unaware that El Niño/Southern Oscillation (ENSO) has a larger impact on pasture growth than rainfall.

Graziers prefer to access their climate information via the Internet, email and print media. The results from the second survey indicated higher use of these methods compared to the first survey. The number of respondents with Internet access also increased from 75% to 86% in the second survey, however this result was not significantly different. "Fax back" decreased from 39% in 2000 to 12% in 2003 ($P<0.05$).

DISCUSSION

Self-rating questions portray graziers' perceptions of their knowledge. These results indicated that there was a small decline over the three years. We suspect this was due to 'optimism bias' where people tend to hold overly favourable views of their abilities in many social and intellectual domains (Kruger and Dunning 1999). In this instance graziers rated their own knowledge and skill higher at the beginning of the project, but once they learnt more about climatic concepts and their applications, they realised that their knowledge wasn't as high as initially thought. This explains the apparent decline in knowledge that was evident in the self-rated section of the second survey, but was not evident in the test question section.

The upward trend in knowledge shown by using the test questions indicates that the climate project activities completed between 2000 and 2003 may have contributed to the increase in knowledge and awareness of climatic concepts in western Queensland. As there was no perception involved with these questions, the results also provided us with valuable information in terms of gaps in knowledge that graziers may have in relation to climate information.

The results from the first survey indicated that graziers prefer to access their climate information through the Internet, email and newsletters. This prompted us to move our extension activities away from workshops and field days and begin publishing a quarterly newsletter *The Season Ahead*. The results from the second survey strengthened those from the first with an even stronger preference for 'self-learning' methods of obtaining information. This supports the view that graziers like to access relevant information at a time that best suits them rather than attending workshops, field days and conferences which can be time consuming and inconvenient. The increase in the number of graziers with access to the Internet also lends support to the idea that the Internet and email are fast becoming the most favoured ways of accessing climate information in western Queensland.

ACKNOWLEDGEMENTS

This work was funded by the Natural Heritage Trust through the National Landcare Program. The time and input from the graziers who completed the surveys is gratefully acknowledged.

REFERENCES

Keogh, D.U., Bell, K.L, Park, J.N. and Cobon, D.H. (2003). Formative evaluation of climate-based decision support information for graziers in western Queensland. *Australian Journal of Experimental Agriculture*, 43: 233-246.

Kruger, J. and Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, 77: 1121-1134.

PROCESSES FOR USING CLIMATE-RISK-MANAGEMENT INFORMATION IN RANGELAND ENTERPRISES

Colin J. Paull

QCCA, Department of Primary Industries and Fisheries, 80 Meiers Road, Indooroopilly Qld 4068

INTRODUCTION

Graziers in Queensland (Qld) currently have a range of decision-support information available to them on current and forecasted seasonal conditions. This includes spatial mapping information down to locality scale (e.g. Aussie GRASS products), and outputs from a range of tools (e.g. DroughtPlan, Rainman and StreamFlow) at property, paddock or point level. Such information can be valuable in making profitable business decisions. Recent surveys in the rangelands of Qld were concerned with users of SOI Hotlines (Paull and Peacock 2003), benchmarking under the national Aussie GRASS Project, evaluating monthly reports on seasonal conditions, and seasonal-climate-forecast (SCF) knowledge and use in western Qld (Park *et al.* 2004). These provided feedback on the SCF information needs of managers, the usefulness of current products, types of decisions in which they were used, preferred presentation formats and delivery methods. This paper reports on findings from a survey conducted in June 2003 – February 2004, pertaining to decision-making processes, including tools and processes used, example management decisions, benefits, and problems encountered. Such a study is a necessary step towards the widespread use of SCFs in integrated business-risk management within rangeland industries.

AIMS AND METHODS

The aims were: to better understand how climate-forecast information was being used by graziers; to assess the value/benefits of using SCF information; to identify problems in using the information; and to identify new areas for developing climate applications. These were achieved by: reviewing feedback from recent surveys; developing a questionnaire, and mailing 133 copies in order to document a range of 'mini' case studies from a purposive sample; assessing the value of SCF information in decision-making; and conducting six more-detailed case studies of selected producers in Central Qld.

RESULTS

Participants returned 36 completed questionnaires (27% return) from Southern Qld (n=13), Central Qld (14), Northern Qld (3), Western Qld (3), NSW (1), and address not given (2). Findings included:

- 67% of respondents said SCFs were not accurate enough. They (n=19) wanted the 'forecasted' climate scenario to occur 50-100% of the time (median 80%, and mean 83%). Several respondents mentioned conflicting forecasts from different sources.
- Respondents were more responsive to a decrease in the probabilities of an important annual climatic event than an increase. They would change normal management decisions when the probabilities were 50% above (n=19), or 40% below (n=13), the all-years probabilities. Some respondents indicated that they were more cautious/sensitive when drought was forecasted (and would tolerate poorer forecast accuracy), compared with a forecast of above-average conditions.
- 11% of respondents had no problems in using SCF information; 28% said the information was difficult to interpret/use; 14% said information was not detailed enough; 11% said the information was not available when needed; and 11% did not use SCF information.
- In the example decisions that were documented, there was a high correlation between the perceived accuracy of the SCF and the degree of influence of the SCF on the decision. 67% (n=10) said their perception of forecast accuracy was 'fairly accurate' or 'very accurate', while 53% (n=8) said the SCF was 'fairly influential' or 'very influential' on their decision.

- While 33% of respondents said SCF information had been 'quite valuable' to 'very valuable' to them, 67% said it had been of 'little value' or 'some value'.
- The median profit from example decisions (n=5) was $25,000 – the range was $5000 to $600,000.

DISCUSSION AND CONCLUSIONS

Requirements for facilitating use of SCF products in business-risk management are: a SCF system of worthwhile accuracy; timely provision of the customised information needed by clients; up-to-date relevant technical information including threshold values; and client's ability to access and understand the information, and willingness to use it. The feedback highlighted the following issues:

Forecast Accuracy. Perceived inaccuracies of forecasts, confounded by climate-change trends, were undermining confidence in using SCF information. Many respondents expected extremely high accuracy in a SCF system, possibly because of a lack of understanding of probabilities. A few indicated reluctance to use probabilities in decision-making. Comments made were: use the most accurate, reputable forecast supplemented by other relevant information; recognise the trade-off between lead-time and accuracy.
Communication. There was often a communication gap between producers of SCFs and graziers; issuing SCFs involves 'duty of care'. Comments included: avoid contradictory signals; use simple unambiguous language in interpretive comments; tailor forecast outputs to the decision-making process; include threshold values; only quote forecasts that have skill; quote rules-of-thumb where precision is difficult.
Interpreting Forecasts. Many graziers made decisions using 'headline' forecasts, often with inadequate understanding of how the forecast system worked and how to interpret the outputs. Sometimes SCF information was used in major business decisions.
Benefits. Client perceptions of the benefits of using SCFs are important. Quantitatively estimating the profit from using a SCF was difficult (Paull 2002). Financial outcomes from example decisions in this and previous studies varied between worthwhile profit and significant loss (climate-risk management often had a short-term cost). Some graziers recognised non-economic benefits.
Increasing Adoption. Graziers require customised SCF information, often with a longer lead-time. Sharing information helps to market climate-related products; this can be achieved by marketing products to agribusiness and extension specialists. The knowledge and skills of graziers (in climate-risk management), and SCF products/services, can be improved by responding to client feedback.
Managerial Behaviour. Management decisions have sometimes been counterproductive to increasing adoption of climate-risk-management practices – usually in response to political priorities, competitive pressures or shortage of resources (e.g., maintaining an outdated forecast system, exaggerating benefits; and allocating inadequate resources to communication and providing training).

Possible future activities to address the above issues are: develop more accurate SCF systems with longer lead-times; develop and customise specific regional products, in collaboration with leading graziers; make products readily available in an easily-understood format; and provide further training in understanding probabilities, and strategic use of information/integrated use of tools.

REFERENCES

Park, J.N., Cobon, D.H. and Bell, K. (2004). Evaluating grazier knowledge of seasonal climate forecasting in the Mitchell grasslands of western Qld. Proc. Aust. Rangelands Soc. Conference, Alice Springs, July.

Paull, C. J. (2002). The value and benefits of using seasonal climate forecasts in making business decisions. Department of Primary Industries Qld, Project Series QO02012, November.

Paull, C.J. and Peacock, A. (2003). Survey of users of the DPI SOI Hotlines. Department of Primary Industries Queensland, Information Series QI03060, October.

CLIMED: A NATIONAL CLIMATE-RISK-MANAGEMENT TRAINING COURSE OF VALUE TO RANGELAND INDUSTRIES

C.J. Paull [1], D.A. George [2], J.F. Clewett [2] and W. Allen [3]

[1] Qld Centre for Climate Applications (QCCA), DPI&F, 80 Meiers Road, Indooroopilly Qld 4068
[2] PPS, Dept. of Primary Industries and Fisheries (DPI&F), PO Box102, Toowoomba Qld 4350
[3]. AgForce Queensland (Qld), PO Box 13186,George Street, Brisbane Qld 4003

THE NEED AND PROJECT OUTLINE

The Australian climate is one of the most variable in the world. Better understanding of this variability, and how to use seasonal climate forecasts, is essential for maintaining profitable rural industries and managing pasture resources sustainably. The last decade has led to improvements in seasonal climate forecasts and their accuracy, which has helped us with this understanding, and in better forecasting climatic variability. Some graziers are now using this information to improve their drought preparation, resource management and production.

In the past, vocational education and training has not adequately provided for education in applied climate. There was a lack of skilled trainers, resource materials and course content. However, recent accreditation of a new Unit of Competency in applied climate was an important step towards correcting the situation. In response to this situation, the ClimEd Project addressed these issues by developing an accredited national course based on the Unit of Competency, and testing delivery of it. The project was co-led by AgForce and DPI&F Qld. Production of technical material was coordinated by climate-risk-management specialists within DPI&F Qld. A Steering Committee made up of representatives of rural industry, Bureau of Meteorology, technical experts, state agencies and the education / training sector, managed the project.

The aims of the project were to provide a range of training resources, and a process, that assisted agriculture, agribusiness, mining and tourism enterprises with strategic management and planning to address climatic risk. The educational content and process were designed to: satisfy the broad needs of this range of industries; maintain a standard equivalent to the Australian National Training Authority (ANTA) Level 5 benchmark; and cover satisfactorily the elements of competency, and their associated performance criteria, specified in the Unit of Competency RTE5523A–Develop Climate Risk Management Strategies (ANTA 2000).

METHODS

The performance criteria for the Unit of Competency are: surveying climatic and enterprise data; analysing climatic risks and opportunities; and developing climatic risk management strategies. The process for completing the Project included: conducting a needs survey; preparing resource materials; conducting a pilot workshop; training trainers; and evaluating the success of the project by measuring the 'end result' and 'practice change' during the project.

RESULTS

The main outcome was development of nationally-endorsed course materials, for better management of our variable climate for economic, environmental and social benefits. There was also improved understanding of effective learning processes and training delivery.

The materials developed include: Participant Manual; Project Assessment Booklet; Trainer Guide; and Overheads. The Participant Manual covered the following units:

1. A *strategic approach* - investigating climate, weather and business;
2. *Weather and climate* - assessing weather options and evaluating climate processes;

3. *Impacts* - analysing the influence of weather and climate on performance of land and water systems (for example, a pastoral production system);
4. *Options* - exploring alternative options for business and environmental management;
5. *Plans* - developing strategic plans for better management of climatic and weather risk; and
6. *Decisions and actions* - establishing methods to monitor and respond to climate and weather information in business.

RELEVANCE AND POTENTIAL VALUE IN RANGELANDS

There is scope for those in rangeland industries to improve their knowledge and skills pertaining to effective and profitable climatic risk management, through a strategic approach to business decision-making. The ClimEd Program has the potential to improve business management in pastoral industries, and also natural-resource management. Its content is consistent with the needs of pastoral industries, and complements and enhances the training currently available in business management, land management and animal husbandry which may not adequately cover climatic issues.

At all trial workshops, a focused session was conducted on strategic management for climatic variability in pastoral industries, which involved both presentations and discussions with participants from pastoral areas. It covered assessing climatic impacts, and identifying and comparing options for responding to a particular seasonal climate forecast or situation. The following points were highlighted: there is a need to better understand climate and causes of variability; analytical tools and forecasting tools are valuable resources; the pasture/production system and its interaction with climate are complex; and strategic and tactical approaches incorporating climate-risk-management into pastoral business decisions are beneficial.

Participants were trained to use tools and decision-support information available in packages such as Australian Rainman and DroughtPlan (available on CD), and Aussie GRASS (available on Internet). The main areas where this information may improve pastoral decisions are long-term carrying capacities, stocking rates, pasture management, mating, production goals, purchases of feed/supplements, planting pastures/fodder, marketing and cash-flow budgeting.

After June 2004, this Unit of Competency will be offered at selected agricultural colleges, vocational colleges, registered training organisations and tertiary institutions. It will address the needs of those involved in pastoral industries. It is anticipated that participants in a particular course, conducted outside educational organisations, will be engaged in similar enterprises within the same region. Accredited trainers will use mainly local specialists in climatic risk management for technical support. FOR FURTHER INFORMATION contact: Col Paull (07) 3896 9587 or Wendy Allen (07) 3236 3100.

ACKNOWLEDGEMENTS

The ClimEd Project was funded by FarmBis - a Program of the Department of Agriculture, Fisheries and Forestry Australia.

REFERENCES

Australian National Training Authority (2002). *Rural Production Training Package RTE02*. ANTA Print Version 1.00.

Trapnell, L.N. and Fisher, W.W. (1993). Incorporating risk into decision support and farm business management systems. Proceedings of a National Workshop held in Melbourne 9-11 November 1992. Editors. Victoria Department of Agriculture, Melbourne.

STUDIES ON CALOTROPE (*Calotropis procera*) IN NORTHERN AUSTRALIA

T.J. Robinson and B.M. Alchin

University of Queensland, Gatton, Qld 4343

BACKGROUND

Calotrope (*Calotropis procera*), also known as 'rubber bush', is an exotic weed from Africa and Asia which has invaded tropical and sub tropical rangelands in northern Australia. The plant is a soft wooded, perennial shrub or small tree growing to 4 m high. The tap root reaches depths of 1.7 to 3.0m.

Models have indicated that it has the potential to further invade vast areas across northern Australia – on most soil types (from cracking clays to coarse sands) where the average annual rainfall (AAR) ranges from 150 to 1000 mm. Plants have also been observed on well drained soils in localities where the AAR is as high as 2000 mm. Current infestations are in habitats such as river banks, native pastures, abandoned cultivation paddocks, coastal fore dunes and mining sites. Calotrope has the potential to become a serious problem in rangelands by suppressing pastures and interfering with stock handling.

The potential for calotrope to spread rapidly in northern Australia is enhanced by its high seed production and wind dispersal mechanism (the seed structure includes a papas). Calotrope can be toxic to stock. It may suppress establishment of other species due to its allelopathic properties.

STUDIES ON CALOTROPE

Review of current knowledge and research

There has been substantial overseas research into the plant's characteristics and properties, particularly for medicinal purposes. However, there has been very limited research into the ecology of calotrope. Current research in Australia includes several herbicide trials being conducted by government departments across northern Australia. Commercial herbicide treatment of calotrope near Katherine in the NT indicated that 'Garlon 600' at 1:60 with diesel applied as basal bark application was very effective; the cut-stump method was relatively ineffective with the same chemical (Desailly, *pers comm.*).

Several aspects of calotrope were studied in this project, *viz.* temperature requirements for germination, seed production and plant interaction with buffel grass (*Cenchrus ciliaris*).

Temperature requirements for germination

Seeds were collected in April 2003 from a location 60 km north-east of Charters Towers on the Burdekin River in north Queensland. Thirteen plants were randomly selected within a stand and nylon sampling bags placed over a total of 24 randomly selected pods. Seeds from individual pods were kept separate for the germination test.

A thermogradient plate was used to provide a range of ten temperatures for germination. The minimum temperature was set at 10^0C and the maximum temperature set at 45^0C. Individual groups of 50 seeds were placed under each temperature treatment. This process was replicated twice.

The seeds were not subjected to any influence of photoperiod. Previous experiments showed little difference in results between seeds subjected to 24 hours of darkness and 12 hour dark/light rotations (Vogler and Brooks 2001). Germination was recorded as occurring if the radical was protruding 3 mm from the seed coat. The seeds were monitored daily over a 12 day period for each replicate. A summary of the results is in Table 1.

Table 1. Germination of calotrope (*Calotropis procera*) seeds in a thermogradient plate.

Temperature (^{0}C)	10	14	18	22	26	30	33	37	41	45
Germination (%)	0	0	1	34	81	50	20	1	0	0

It was concluded that:

- Maximum germination occurs at approximately 26^{0}C.
- Significant germination occurs between approximately 20^{0}C and 35^{0}C.
- Germination may occur at temperatures as low as 18^{0}C.
- Germination may occur at temperatures as high as 37^{0}C.
- Germination will probably not occur below approximately 16^{0}C.
- Germination will probably not occur above approximately 40^{0}C.

There was a 'lag phase' of approximately four days before the first germination was recorded. Most of the germination then occurred in the following five days, declining significantly through to the 12th day.

The wide range of temperatures in which calotrope can germinate means that it will have a significant period throughout the year in most localities in which it can respond to rainfall. The maximum and minimum temperatures for germination may provide a guide for land managers on the time-frame in which they can control calotrope in the seedling stage.

Seed count

Counts of individual seeds indicated that there was an average of 500 seeds per pod. This indicates that calotrope is a prolific seeder, and even an individual plant would provide ample opportunity for rapid encroachment.

Interaction with buffel grass

Previous work in W.A. indicated that calotrope may be suppressed by buffel grass (Cheam 1984). However, observations at several sites across north Queensland indicated that calotrope can grow actively within buffel grass stands.

RECOMMENDATIONS

From the serious threat posed by calotrope, it is strongly recommended that further research be conducted into the ecology of calotrope in Australia to provide the basis for effective management and control.

REFERENCES

Cheam, A.H. (1984). Allelopathy in buffel grass (*Cenchrus ciliaris* L.). Part 1. Influence of buffel grass association on calotrope (*Calotropis procera*). *Aust. Weeds* 3: 133-136.

Vogler, W. and Brooks, S. (2001). Unpublished data – results of germination trials on *Calotropis procera*. QNRM Topical Weeds Research Centre, Charters Towers, Qld.

MANAGING RISK – DELIVERING FIRE INFORMATION TO REMOTE AREAS

M. Steber [1], M. Tovar [1] and N. Raisbeck-Brown [2]

[1] Satellite Remote Sensing Services, Department of Land Information, Leeuwin Centre, 65 Brockway Road, Floreat WA 6014
[2] Ecomap, 65 Walcott St, Broome WA 6725

INTRODUCTION

Although many pastoralists use the Department of Land Information's (DLI) Satellite Remote Sensing Services (SRSS) website (http://www.dli.wa.gov.au/corporate.nsf/web/Fire+Hotspots) to view the fire hotspot information from the NOAA satellites, slow connection speeds and high access costs have previously limited the type of information and services that can be provided over the Internet. Fire information is most valuable when it is viewed in near real time. SRSS decided that providing an automated fax service would reach a greater number of pastoralists and be cost effective to both SRSS and the end user. Feedback received by SRSS at the end of 2002 showed that many pastoralists were looking at broadband access to the Internet. During 2003 an email service was offered, with colour and a higher resolution, as an option to the original fax service.

DATA

The fire hotspot locations used in the automated fax and email service are automatically produced each morning on a UNIX workstation at SRSS. The locations are calculated using an algorithm that is based on Lee and Tag (1990) with ideas taken from Flasse and Ceccato (1996). The data used are from the Advanced Very High Resolution Radiometer (AVHRR) sensor onboard the National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellites. The data are made available to SRSS through its membership of the Western Australian Satellite Technology and Applications Consortium (WASTAC). Data are collated from both NOAA-16 (passes over at approximately 02:00 WST) and NOAA-12 (passes over at approximately 04:30 WST).

METHODOLOGY

All 1:250000 map sheets for WA and NT have been converted to ERMapper format. The map sheets are used as the backdrop for each client's region of interest (ROI). The fire hotspot locations are in latitude/longitude format as a text file. A program was written in IDL (Interactive Data Language) to combine these two datasets. The program produces images in two formats; GIF format for the fax software, RightFax, and JPEG format for the email software, mpack. This program runs every morning at 8:00 and the faxes and emails are sent out at 8:30. The status of the faxes is checked at about 9:30 and any that may have failed (usually due to the client's fax machine not being turned on) are resent. The GIF images are black and white and the fire hotspots are marked with a black square. The JPEG images are coloured and the fire hotspots are marked with a red square. A registration form was sent to pastoral stations and government agencies with interests in the pastoral region. Each station or agency that returned the form was contacted by phone and then sent a test fax or email of their ROI. If the test was satisfactory, the pastoralist's details were added to the automated system.

FUTURE DEVELOPMENTS

Later this year we hope to introduce an afternoon service (at about 1:30) using the fire hotspot locations detected on the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor onboard the Terra satellite. Next year clients will be given the option of having ArcView shapefiles mailed to them. This would allow them to use the fire hotspot locations in ArcView GIS and ArcExplorer and build a history of fire hotspot activity on their property.

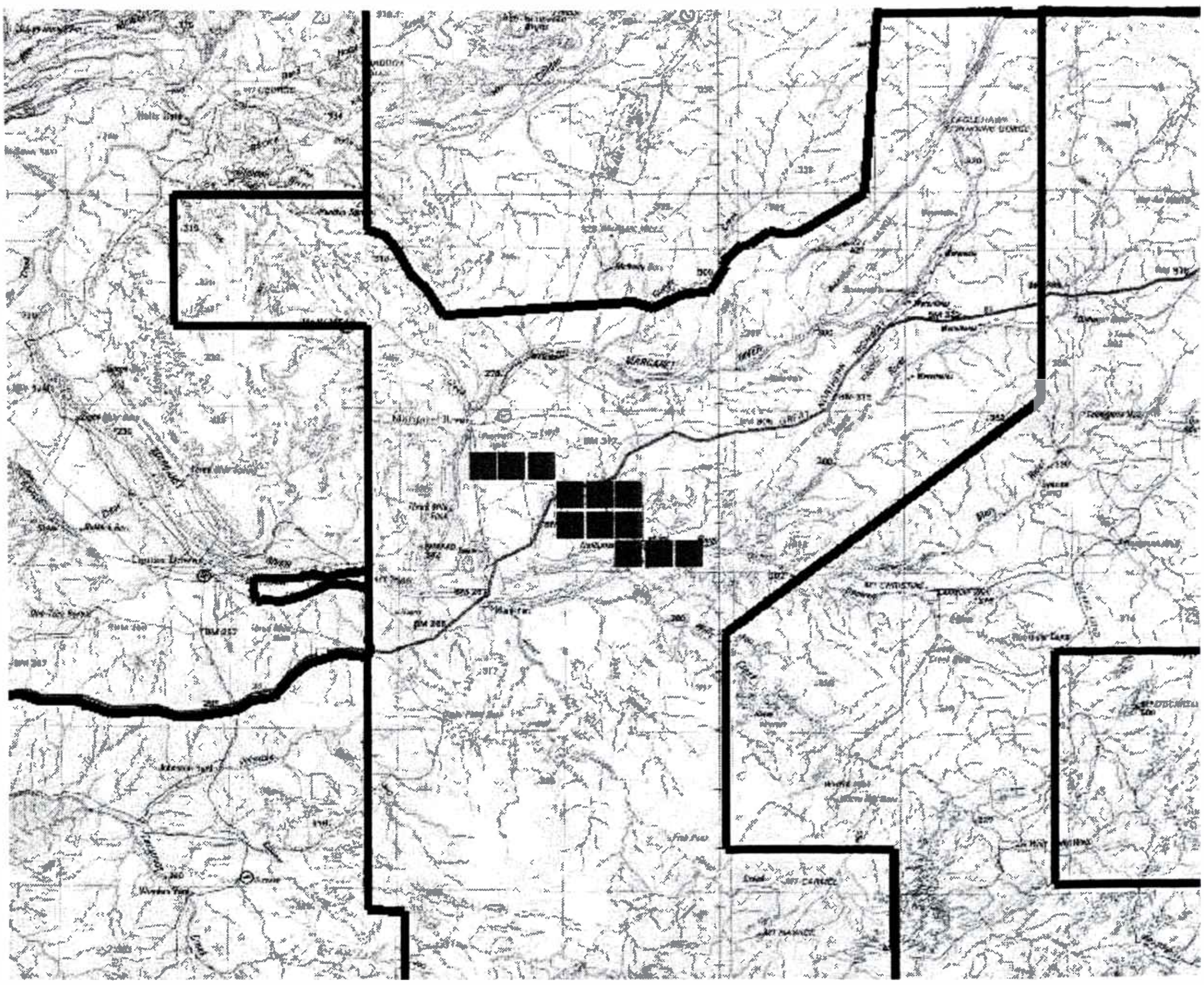


Figure 1. Sample fire hotspot email product.

REFERENCES

Lee, T.F. and Tag, P.M. (1990). Improved detection of hotspots using the AVHRR 3.7 μm channel. *Bulletin of the American Meteorological Society* 71: 1722-1730.

Flasse, S.P. and Ceccato, P. (1996). A contextual algorithm for AVHRR fire detection. *International Journal of Remote Sensing,* 17: 419-424.

SEEING THE WHOLE SYSTEM AND "KNOWING WHERE TO TAP", LOW INPUT, HIGH EFFICIENCY RESTORATION TECHNIQUES

Peter-Jon Waddell

Centre for the Management of Arid Environments (CMAE), Department of Agriculture and Curtin University of Technology, Locked Bag 22, Kalgoorlie WA 6433. E-mail: pjwaddell@agric.wa.gov.au

BACKGROUND

Australia's rangelands have a history of degradation. This legacy arises from inappropriate management strategies and a poor understanding of rangeland ecosystem interaction and the patterns and processes within the sub-catchments that comprise them. As human workforces decline through most of the rangelands it is becoming increasingly more important that any form of restoration is realistically balanced between the investment of costs and labour against the long-term effectiveness of the treatment.

Many restoration techniques have focussed on large areas that show the worst symptoms of land degradation. Mechanical or other interventions in profoundly degraded areas are expensive and localised, when often the causes may be off-site and the dysfunction considerably greater than the visually worst areas chosen for treatment. Today the economics of intensive mechanical treatments are questionable and have limited appeal to private land managers. Many restoration treatments involving mechanical intervention have largely failed because; the solutions sought were too simplistic, the treatment did not persist long enough to be effective, and success was too often dependent on favourable climatic conditions following up the treatment (Sparrow *et al.*, 2003; Tongway and Ludwig, 1996). In areas where mechanical intervention has resulted in success it may have been many years before an adequate return matched the initial capital investment, financially as well as ecologically (Bastin, 1991).

RESETTING BASE LEVELS AND DEALING WITH LANDSCAPES

Understanding how ecosystems interrelate with one another is essential before broad ecosystem management can begin. In attempting any form of restoration or rehabilitation it is necessary to have an understanding of broad scale catchment function (Pringle and Tinley, 2003), as well as how scarce resources are regulated within each landscape type (Ludwig *et al.*, 1997). Understanding the broader context of where a degraded site is situated within the catchment will allow restoration strategies to be implemented that will work with the landscape, not against it.

Working together through the Ecosystem Management Understanding (EMU) Process (Pringle and Tinley, 2001) land managers and ecologists are using local knowledge to strategically implement restoration techniques to address land degradation, on pastoral leases in the southern rangelands of Western Australia. With present day station workforces greatly reduced and large scale mechanical treatments dauntingly expensive, land managers need to be strategic where they invest their time and money when wanting to engage in restoration activities. In trying to avoid intensive mechanical treatments, the EMU Team is attempting to address catchment dysfunction through restoration techniques of low input, suitable for small station workforces, but which will have wide ranging and lasting effectiveness.

Knowing where to tap! This is a key feature of the EMU process. Focusing on the preservation of the most intact country is seen as a priority. Such intact landscapes are often of significant pastoral importance, such as grassy floodplains or chenopod shrublands, or they are areas of local or regional significance, such as wetlands that offer an important role in drought buffering. If immediate threats to these valuable landscapes exist then the processes driving those threats need to be determined. It is very likely that the immediate local issues are but part of a broader system. Seemingly unrelated sequences of degradation along a catena of landscapes are quite possibly the far-reaching, related consequences of a dysfunctional catchment disrupted at a particular control point.

Changes bought about by a reduction in base levels (Pringle and Tinley, 2003) to the driving processes of erosion (Pickup, 1985) can initiate wide spread symptoms of degradation. When an influential base level is cut, erosion progresses upslope; stripping topsoil, desiccating and fragmenting grasslands and chenopod shrublands, breaching ephemeral wetlands and draining floodplains as incisions leave them perched on fluvial landscapes (Tinley, 1982). Once erosion is underway it is likely to continue until a new equilibrium has developed.

After identifying and assessing the driving processes responsible for causing degradation within a catchment, in terms of disruption of drainage networks, it may be possible to attempt intervention at strategic points. Working in the upper-most parts of the catchment, where feasible, and moving downstream, damaged local base levels may be reinstated by using a variety of sieves to calm the water. Filtering, rather than blocking, slows the water assisting in the preconditioning of the drainage network for treatments further down the catchment. Gully heads and certain confluences of incised channels, where conditions are appropriate, need to be stabilised to assist with the calming process. Strategic placement of water calming treatments is crucial to the process of attempting to heal a dysfunctional catchment. This in turn will benefit the main aim of preserving valuable and intact landscapes, before they are lost or become scattered remnants as fragmentation and desiccation continues unchecked. Such "low input" restoration techniques are being trialed by many land managers. Two major catchment restoration projects involving multiple properties are underway in the Murchison and Gascoyne River catchments as part of the Desert Knowledge CRC programme.

ACKNOWLEDGEMENTS

Thanks are due to Hugh Pringle and Annabelle Bushell for constructive comments.

REFERENCES

Bastin, G. (1991). Rangeland reclamation on Atartinga Station, central Australia. *Aust. J. Soil & Water Conserv.* 4(2): 18-25.

Ludwig, J.A., Tongway, D.J., Freudenberger, D.O., Noble, J.C. and Hodgkinson K.C. (1997). *Landscape Ecology, Function and Management. Principles from Australia's Rangelands.* CSIRO Publishing, Melbourne.

Pickup, G. (1985). The erosion cell – a geomorphic approach to landscape classification in range assessment. *Aust Rangel J.* 7: 114-121.

Pringle, H.J.R. and Tinley, K.L. (2003). Are we overlooking critical geomorphic determinants of landscape change in Australian rangelands? *Ecol. Mgmt & Restoration* 4: 180-186.

Pringle, H.J.R. and Tinley, K.L. (2001). Ecological sustainability for pastoral management. *J. Agric. West. Aust.* 42: 30-35.

Sparrow, A.D., Friedel, M.H. and Tongway, D.J. (2003). Degradation and recovery processes in arid grazing lands of central Australia. 3: Implications at landscape scale. *J. Arid Environs.* 55: 349-360.

Tinley, K.L. (1982). The influence of soil moisture balance on ecosystem patterns in southern Africa. *In: Ecological Studies.* Vol. 42: *Ecology of Tropical Savannas* (Eds B.J. Huntley and B.H. Walker.), pp.175-192. Springer-Verlag, New York.

Tongway, D.J. and Ludwig, J.A. (1996). Rehabilitation of semi-arid landscapes in Australia. I. Restoring productive soil patches. *Restoration Ecol.* 4: 388-397.

ENVIRONMENTAL MANAGEMENT SYSTEMS - THE CENTRAL AUSTRALIAN PASTORAL EXPERIENCE

D. Walsh

Centralian Land Management Association, PO Box 2534, Alice Springs, NT 0871

ABSTRACT

This paper outlines the aims and early findings of a project exploring Environmental Management Systems (EMS) in the Central Australian beef industry. This project is one of 15 funded under the Commonwealth Government's EMS National Pilot Program in Agriculture.

INTRODUCTION

An EMS is a process used by businesses to identify and achieve continuous improvement in environmental management. The process is about identifying where you are now with your management, where you want to be, how you are going to get there and how you're going to know you're achieving it. In addition to improved environmental management, the potential benefits of EMS can include increased production efficiencies and yields, cost savings and being able to prove you're "doing the right thing". Whether any of these benefits will be realised on pastoral stations in Central Australia is yet to be determined.

Environmental management on Central Australian pastoral lands happens at a vast scale. Individual families are responsible for the management of total grazing pressure, water, weeds, erosion, fire and feral animals over thousands of square kilometres. The pastoral industry's landcare group, the Centralian Land Management Association (CLMA), has provided practical support for these activities for 15 years and continues to enjoy a high level of membership. The owners and managers of 15 member properties volunteered to participate in a pilot project to test the practicality, costs and benefits of EMS. The participants cover a wide geographical area and their environmental priorities vary accordingly.

We believe that Central Australia will be one of the most challenging environments for developing and assessing EMS. This is because the region is characterised by:

- Family owned businesses with limited financial and labour resources.
- An arid to semi-arid climate, with high climate variability.
- Large catchments with complex natural resource management issues.
- An extensive, low input production system based on native vegetation (average property size 3,500 sq km).
- Remoteness from the consumer, both physically and in the supply chain.

WHAT IS OUR PROJECT HOPING TO ACHIEVE?

The aims of our project are:

- To test the value of EMS in the identification, implementation, demonstration and communication of sustainable natural resource management within the Central Australian pastoral industry.
- To allow producers to determine the practicality and value of EMS for achieving improved business and resource management outcomes.
- To identify how EMS could help to improve resilience in variable combinations of climate and market conditions, which impact on the sustainability of the natural resource base and family businesses.

- To create links between property-level EMSs and soon to be developed regional Natural Resource Management plans.
- To value-add the existing pastoralist-owned monitoring system (Centre Land Watch).
- To identify EMS tools and approaches that best support the aspirations of pastoral families in arid environments.

WHAT HAVE WE DONE TO DATE?

The CLMA was able to broker agreements with government and non-government organisations to supply all known natural resource data relating to the fifteen participating properties. With the assistance of a CLMA project officer, this information has been integrated with producer knowledge to develop comprehensive environmental summaries for each property. These summaries provide the context for producers to identify environmental impacts, prioritise works, develop management and monitoring plans and showcase their stewardship. There have also been some unexpected benefits for the agencies supplying information. The demand for property-specific natural resource information has lead to routines being developed to allow more efficient extraction of information from databases. This has helped some agencies provide similar products to other clients quicker than they were able to in the past. Furthermore, producers have been able to provide feedback on the accuracy of the map products and information provided by the agencies, which in turn has improved the quality of the datasets.

Some participants have found that the EMS process has helped them to record the history of their past and current environmental management activities which will, over time, become a benchmark against which they can measure changed attitudes and practices. Some have also recognised the potential to integrate EMS with their existing organic certification, Cattlecare accreditation and/or property development initiatives.

Although there is an international standard for EMS (ISO14001), our producers are not seeking certification at this stage. The significant costs of ongoing audits, the mountain of paperwork and the absence of market drivers are barriers to certification for the pastoral industry (Francis 2003, Steward and Banney 2003). Instead, our approach is to develop and implement EMSs that are consistent with the standard so that producers can easily adapt their EMS if they wish to seek certification in the future.

During the next 12 months, participants will be identifying their most significant environmental issues and will develop work plans to address these. This will be followed by a monitoring and review phase with the project due to finish in July 2006.

ACKNOWLEDGEMENTS

This pilot project is partially funded by the Natural Heritage Trust. CLMA acknowledges the support of our partners in this project: the Department of Business, Industry & Resource Development, Department of Infrastructure, Planning & Environment, CSIRO (Alice Springs), Northern Territory Cattlemen's Association and the Threatened Species Network (Alice Springs).

REFERENCES

Francis, P. (2003). EMS a valuable tool if producers are in control. *Australian Farm Journal*, September 2003: 31-35.

Steward, N. and Banney, S. (2003). Implementing ISO14001 Environmental Management Systems within the red meat industry - what can we learn? *In* "Agriculture, business and the environment - advancing the EMS debate". CD-ROM Proceedings of the 3rd National Conference on Environmental Management Systems in Agriculture. Tanunda, South Australia. 10-13 November 2003.

PLANT RECOVERY AFTER FIRES OF DIFFERENT INTENSITIES: SOME SHORT-TERM OBSERVATIONS FROM CENTRAL AUSTRALIA

L. Walton [1#] *and D. Walsh* [2]

[1] 19 Banksia Street, Alice Springs NT 0870
[2] Centralian Land Management Association, PO Box 2534, Alice Springs NT 0871
[#] This project was completed by the primary author when she was the recipient of the Heaslip Arid Zone Research Scholarship. The scholarship, which is funded by a local pastoral family, aims to encourage a local high school student to undertake scientific research in the rangelands.

ABSTRACT

The main objective of this project was to observe short-term changes in the regeneration of trees, shrubs and herbage species after fires of different intensities on pastoral land near Alice Springs. After the fires, ground cover increased on both burnt sites, however, cover increased faster on the cool burn site than the hot burn site. The growth rate of species was higher on the cool burn site, as were the number of plants that flowered and set seed. Interestingly, some plants that appeared to have been killed by the intense hot burn resprouted during the study.

INTRODUCTION

Exceptionally high rainfall in 2000 and 2001 followed by severe frosts in the winter of 2002 created high fuel loads in Central Australia. This resulted in the biggest fire seasons since the 1970's in the Alice Springs district. We studied plant regeneration on two burnt sites near Alice Springs. One site had experienced a "cool" burn that had moved slowly and occurred during the night. The "hot" burn site experienced an intense and fast moving fire that burnt into the canopies of the trees (Grant Heaslip, *pers. comm.*). Data were collected to see which species germinated or resprouted after the fires, how fast they grew and if any flowered or seeded. Data were also collected on a site that had not been burnt for comparison.

For this study, it was predicted that:

- Ground cover and pasture growth would increase faster on the cool burn site than the hot burn site due to less harsh surface conditions.
- Trees and shrubs on the hot burn site would not resprout due to the extensive damage they had suffered.

METHODS

The three research sites for this project were located on Bond Springs station, approximately 20 km north of Alice Springs. Site 1 was the 'unburnt' site and had not been burnt for 25 years. Site 2 was classified as a 'cool burn' site as the fire, which occurred in November 2002, was of low intensity (Grant Heaslip *pers. comm.*). Site 3 was classified as a 'hot burn' site as the fire was an intense fire-storm that obliterated most plants in its path, leaving the earth bare and plants charred (Grant Heaslip *pers. comm.*). Within each of these sites, three 1 sq m quadrats were randomly selected as the plant sampling locations. These permanent quadrats were used to measure the number, growth, mortality and reproduction of all species present. They were also used to gain an appreciation of cover change over time. The plant measurements were repeated three times over the summer of 2002/3. A full description of the methodology can be found in Walton and Walsh (2004).

RESULTS AND DISCUSSION

Copperburr and mulga grass significantly increased in height on the unburnt site but the oatgrass and umbrella grass significantly decreased. Observations indicate that the decline in oatgrass height was due to the death of many small seedlings that germinated after the November rains. The reduction in height of the umbrella grass was due to grazing. On the cool burn site, tar vine, caltrop and pea plant increased significantly in height whilst swainsona, paddy melon and umbrella grass decreased in height. Observations confirmed that the swainsona and paddy melon suffered mortality and that the umbrella grass was grazed. On the hot burn site, whitewood, silky heads, sida, grey indigo and an unknown grass showed increases in height over the study. Interestingly, mortality did not appear to be higher on the hot burn site, which might have been expected due to the harshness of the microenvironment around the plants.

Ground cover on all three sites increased during the project (Walton and Walsh, 2004). Even though many of the small plants that germinated actually died, the more-established plants, such as the grasses, larger shrubs and resprouting trees continued to grow and thrive. As predicted, the cover on the cool burn site increased faster than on the hot burn site.

High plant mortality was evident on all three sites. Caltrop seedlings had the highest mortality on the unburnt site (Walton and Walsh, 2004). Oatgrass seedlings had the highest mortality rate on the cool burn site. The high mortality measured on all sites (including the unburnt site) suggests that small seedlings are very prone to high summer temperatures.

With regards to reproduction, it was found that only herbage species were able to recover, flower and set seed during the study. No shrub species reproduced during the study. The species that reproduced on the unburnt and cool burn sites included 8-day grass, mulga grass, oatgrass, caltrop and swainsona. No flowering or seed set was observed on the hot burn site. A harsher environment, caused by higher evaporation on the bare soil may have stopped the plants from getting enough moisture to grow to sexual maturity on this site.

Species did resprout on both burnt sites, however, more resprouting occurred on the cool burn site. The species that showed basal resprouting included fork-leafed and long-leafed corkwood, acacia bush, broombush, witchetty bush and whitewood. The only woody species that did not resprout on the cool burn site was spiny saltbush.

CONCLUSION

Plant regeneration occurred on both the burnt sites studied, with the main difference being the time taken for plants to regenerate and reproduce. As predicted, recovery was faster on the cool burn site compared to the hot burn site. Our second prediction, that badly burnt shrubs and trees on the hot burn site would not resprout, was not supported.

ACKNOWLEDGEMENTS

The financial assistance and enthusiastic support of the Heaslip family of Bond Springs is gratefully acknowledged. We would also like to thank Chris Tudor of St. Philips College, the Centralian Land Management Association, Bureau of Meteorology and Bushfires Council for assistance with this project.

REFERENCES

Walton, L. and Walsh, D. (2004). Plant recovery after fires of different intensities: some observations from Central Australia. *Range Management Newsletter* 04/1: 6-10.

I HAD THE RIGHT NUMBER OF SHEEP, BUT THE WRONG AMOUNT OF RAIN

Ian Watson

Centre for Management of Arid Environments and Department of Agriculture Western Australia,
PO Box 483 Northam, WA, 6401

ABSTRACT

Pastoral managers who over-estimate the chance of good rainfall are likely to carry too many livestock and retain them too long into a dry period. By having an overly optimistic, rather than realistic, view of rainfall pastoralists lose their ability to critically judge their stocking decisions against their rainfall environment. This is particularly the case in arid environments where average rainfall is low and variability high.

INTRODUCTION

Perhaps the most important set of operational decisions a pastoral manager can make are those that *"get the stocking rate right"*. The penalties for getting it wrong affect both financial and environmental outcomes and can have long-term, permanent impacts on the viability of the pastoral enterprise. Getting the stocking rate right relies on matching animal numbers to land capability in the medium to long term and to feed availability in the short to medium term. The task is not easy. High variability in rainfall, particularly in arid rangelands, means that it is not possible to settle on a single, definitive carrying capacity. Even the concept of "carrying capacity" in such rangelands is seen to be unhelpful (Stafford Smith 1996).

Pastoral managers make stocking rate decisions based on a number of factors. One of the most important of these is an estimate of the amount of rainfall that will be received between one stocking decision and the next (note: this is not based on a forecast, but on historical records). How well the estimate of rainfall is made will depend on how accurate is each manager's perception of the rainfall environment for their station. If that perception is inaccurate, because it is overly optimistic, then when the time comes to review the stocking rate decisions they will be reviewed against unrealistic expectations of rainfall. Poor stocking decisions will be justified by considering the rainfall atypical, rather than considering that stock numbers were too high.

RAINFALL REALITIES AND PERCEPTIONS

Rainfall from Cue (27.43°S, 117.88°E) was used as an example in this paper. The records were generated from the Silo climate surfaces (http://www.nrme.qld.gov.au/silo/) for the period 1895 to 2004. They give an average (i.e. mean) of 223 mm and a median of 201 mm. While the proportion of winter (May-Oct) to summer (Nov-Apr) rainfall was close to 50:50, the coefficient of variation for winter was 51.6 and that for summer was 77.6. The characteristics outlined below are typical for most of the southern rangelands of Western Australia. Winter provides the most reliable rainfall, with good summer rain in a minority of years.

Dry conditions can persist for a long time

Between February 1948 and February 1975, a period of 27 years, Cue did not receive a rainfall event over 100 mm (an event was defined as a period of consecutive wet days, broken by a day in which no rain fell, Stafford Smith and Morton 1990). Over ten years have passed between events of at least 50 mm and almost three years between events of at least 25 mm. There have been five occasions in Cue's 109 year rainfall history when more than two years passed between events of more than 25 mm and four occasions when more than five years passed between events of at least 50 mm.

The longest sequence of below average rainfall was seven years from 1935 to 1941. To compound this, 14 of the next 18 years were also below the mean giving an extended sequence from 1935 through to 1959, in which only four of 25 years exceeded the mean.

Asymmetry of dry and wet conditions

There are more dry years than wet years. For the 109 year record at Cue there have been 62 years above average and 47 years below average. That is, there are 32% more years below average than above.

It takes a lot of dry years to even out the wet ones. For example, a total of 481 mm above average fell at Cue during the consecutive summers of 1998/1999 and 1999/2000. This is equivalent to just over four years of summer rainfall. Assuming the long-term average doesn't alter it will take four years of zero summer rain, or eight years of half average summer rain (and so on) to even out the two very good years.

Management perceptions

Inaccurate perceptions of the rainfall environment are manifested in several ways. If the potential for prolonged dry periods isn't well understood then a succession of poor stocking decisions will be made on the basis that *"We haven't had a good year for a while now, so we are bound to get a good year this time"*. If wet summers are considered typical, then gambling on summer rain becomes a frequent management decision because *"We haven't had the summers we should be getting"*. This leads to an excess of livestock being carried into the driest part of the year. If the asymmetry of rainfall is not well understood then for every year below average received, a year above average will be expected.

The period in which a manager "learnt the trade" can also affect perceptions of the rainfall environment. If a manager's formative years included an atypically wet period, often a sequence of good summer rain, then this may come to be considered "normal". Stocking rate decisions based on these "normal" years will invariably be too high, with the risk that the low rainfall will be considered the cause of having more stock than feed, rather than the cause being an inaccurate perception of the chance of good rain.

Sequences of good seasons tend to recalibrate carrying capacities upwards in the minds of many managers. At Cue, the period from 1992 to 2001 saw seven out of ten years above average. While high numbers of livestock could comfortably be carried during such a period, there is a risk that stocking rates will be permanently recalibrated upwards.

CONCLUSIONS

Judging the number of stock to put into a paddock is not easy and from time to time the wrong decision will be made. However, it is important that when stocking rate decisions are reviewed, as part of a learning cycle, they are reviewed against realistic chances of rainfall and not optimistic perceptions.

ACKNOWLEDGEMENTS

The author acknowledges the support of the Land Water and Wool "Managing Climate Variability" sub-program and the Silo meteorological data project.

REFERENCES

Stafford Smith, M. (1996). Management of rangelands: paradigms at their limits. *In* 'The ecology and management of grazing systems.' (Eds J. Hodgson and A.W. Illius). CAB International, Wallingford, pp. 325-357.

Stafford Smith, D.M. and Morton, S.R. (1990). A framework for the ecology of arid Australia. *J. Arid Env.* 18: 255-278.

Economic & Social Risk Management
(Poster Group Two)

NATIONAL LANDCARE PROGRAM

Matthew Bolam

NLP State Landcare Coordinator NT, PO Box 1251, Nightcliff, NT 0814

AIM

The aim of the Australian Government's National Landcare Program (NLP) is to increase involvement by industry, farmers and the wider community in landcare and other natural resource management (NRM) activities.

WHY LANDCARE?

As managers of 60% of land and 70% of the water diverted for irrigation, farmer involvement is crucial in achieving the Australian Government's primary industry and NRM goals.

Landcare is a voluntary community group movement aimed at improving land management by putting sustainable agriculture into practice at local, regional and national levels. The NLP recognises that landcare is effective at getting in touch with both rural and urban communities, and at encouraging improved NRM practices amongst primary producers.

Surveys show that landcare is a key entry mechanism into other Australian Government programs and that its members are much higher adopters of sustainable practices. For example, landcare members are twice as likely to use minimum tillage and three times as likely to undertake soil testing. A recent review of the Program found that landcare practices have resulted in improved resource condition at the property level, which is contributing to off-farm public benefits and laying the foundations to meet catchments and regional targets on resource condition. The results of this review are available online at: www.daff.gov.au/landcarereview

Landcare remains a strong community movement that exists independent of government support. Nevertheless, the partnership with government through the NLP is important to ensuring coordinated approaches to NRM.

HOW IT WORKS

The Australian Government provided $39.12 million for the NLP in 2003-04 under the *Natural Resources Management (Financial Assistance) Act 1992.* In the May 2004 Budget the Australian Government announced funding of $159.5 million over four years for the NLP with $39.3 million in 2004-05, $40.2 million in 2005-06 and a further $40 million in each of 2006-07 and 2007-08. Investment in landcare is also provided by the Natural Heritage Trust (NHT) to complement investment in sustainable NRM practices, conserving and restoring habitat and improving the condition of rivers and coastal and marine areas.

The NLP is administered by the Australian Government Department of Agriculture, Fisheries and Forestry and consists of two components:

1. National Component – Investments targeted at projects that have broad scale, rather than regional or local outcomes, and are most effectively undertaken at the national level. Areas of investment in 2003-04 have included:

- Landcare Support (including funding for the Australian Landcare Council, Landcare Australia Ltd and the National Landcare Facilitator)
- National Priority Projects
- Industry Partnerships

- Natural Resource Innovation Grants
- State Landcare Coordinators
- Monitoring and Evaluation

2. Community Support – Investments in on-ground actions. Projects complement priorities identified in accredited or interim NRM regional plans and investment strategies. They are undertaken in partnership and require matching contributions in cash or in-kind. Community Support is delivered via grants through the States to regional NRM bodies and other appropriate organisations.

Activities that have been funded under this component include training for sustainable pasture and cropping systems, promoting implementation of best practice management, demonstration and extension of innovative management techniques that link productivity and sustainability, farm forestry projects, and water management activities.

FUTURE ARRANGEMENTS

Future arrangements for delivery of the NLP, including announcements on project funding, can be found at www.landcare.gov.au or by contacting your State Landcare Coordinator.

NLP STATE LANDCARE COORDINATOR CONTACTS

Northern Territory:	Matthew Bolam Mobile: 0428 330 131 Email: mattbolam@bigpond.com
Western Australia:	Matt Giraudo Mobile: 0428 330 119 Email: MattGiraudo@waff.org.au
South Australia:	Mark Stanley Mobile: 0428 330 128 Email: mark.stanley@epcatchment.com.au
Queensland:	Tony McKew Mobile: 0428 330 121 Email: tony.mckew@daff.gov.au
New South Wales:	John Dalton Mobile: 0428 330 114 Email: john.dalton@rlpb.org.au
Victoria:	Ian Linley Mobile: 0428 330 122 Email: ianlinley@bigpond.com
Tasmania:	Don Defenderfer Mobile: 0428 330 115 Email: don.defenderfer@bigpond.com

PARTICIPATORY APPROACHES TO UNDERSTANDING AGRICULTURAL DEVELOPMENT AND DROUGHT MANAGEMENT IN RANGELANDS

S. Bradford

Rangeland Management Action Plan, PO Box 305, Wentworth NSW 2648

ABSTRACT

Sustainable management of natural resources and development in agricultural productivity through community driven projects has been the highlight of the implementation of the Rangeland Management Action Plan. The Rangeland Management Action Plan has encouraged landholders in the Lower Murray Darling Catchment to be actively involved in the development and implementation of projects to improve natural resource management and agricultural productivity through carrying out best management practices.

During the recent drought, it was felt a deeper understanding of the needs of landholders and managers was required. Community consultation and participation through workshops was used to approach landholders to understand management practices carried out during the drought and develop a clearer understanding of how best management practices can be applied to better prepare and manage drought conditions and maintain productivity.

The usual unwillingness and difficulty to get landholders to attend and therefore participate in projects and consultations has been overcome through adopting adequate participatory learning approaches at open and relaxed community workshops.

INTRODUCTION

The Rangeland Management Action Plan (RMAP) is a community driven organisation working with landholders in the Lower Murray Darling of New South Wales. Recently during the drought, a series of ten workshops "Looking Beyond the Drought" were held throughout the Catchment. The workshops aimed to provide landholders with an opportunity to interact and share ideas, experiences and management strategies that they have implemented and that may have assisted them during the drought. The workshops were structured to provide a platform of open learning, with participants sharing knowledge and experiences from previous droughts, looking at options for recovery, and assessing information and assistance available during the drought.

More than 250 landholders attended the workshops, to contribute to the gathering of information, which was collated to provide feedback to government. While the information is not a quantitative measure of priority issues for agricultural production during the drought, the workshops provided an insight into some issues for landholders during the drought.

This paper presents a summary of issues which were repeatedly discussed at the facilitated workshops to identify how projects and drought management practices can be implemented according to landholders needs and how effective consultation can involve landholders in best management practices.

TOTAL GRAZING PRESSURE

The importance of managing total grazing pressure during the drought is vital to maintaining a level of productivity for landholders in the region. With many properties reducing stock numbers during the drought, the control of feral and native animals to manageable levels is vital. Extensive rabbit warren ripping and control programs were identified as the foremost advantage to properties in controlling grazing pressure. Management of feral goat numbers on properties was also identified. Due to a good market for goats, landholders felt the added incentive to set up traps around watering points to control goat numbers and relieve grazing pressure was a beneficial management strategy.

The installation of controlled water points was a management strategy undertaken which landholders felt also assisted in controlling total grazing pressure. The provision of pipelined water with controlled tanks and troughs rather than open water points was seen as advantageous to retaining pasture and native feed for longer during the drought.

EXCEPTIONAL CIRCUMSTANCES

A major concern raised throughout the workshops was issues of assistance through the current Exceptional Circumstances (EC). Participants felt there is a need for review of the EC criteria as current eligibility measures were deemed to be ineffective and unfair. It was a widespread feeling that Exceptional Circumstances as it stands does not promote the adoption of responsible management practices, which needs to be encouraged. There is a vital need for the government to endorse a more self-reliant principle of management, rather than supply relief, which is continually provided through EC. A common feeling was that the assistance must be means and needs tested and made conditional on the adoption of responsible and sustainable management practices.

As a result of the issues raised concerning Exceptional Circumstances, some recommendations were made. A more user-friendly system should be put in place to promote positive drought management strategies and pre-drought management rather than straight handouts that are misdirected. Also a 'HECS' designed system is required, where a payback arrangement is made, when income returns to a certain level.

CONCLUSION

A number of other issues were raised as part of the workshops including: retention of core breeders and stock feeding, Farm Management Deposits, along with ideas on options for recovery. The community meetings identified that property management plans must recognise the increasing variability of growing seasons and have triggers built into management plans to react to these seasonal conditions. As a result of the community workshops, participants left feeling that the open platform meetings were a good avenue to share ideas and express opinions of drought management and drought assistance. Providing a relaxed environment in familiar surroundings ensured people felt comfortable to express their views and contribute to the workshop. A vital link in the process of community consultation is feedback, with information concerning the issues to be filtered back to the community. Land managers felt actively managing grazing pressure and working together for and during the drought is imperative, and sharing management practices with others was constructive.

ACKNOWLEDGEMENTS

The information in this paper has been collated from the views of landholders who attended the workshops. Thank you to all those people who came along to contribute.

PROPORTIONAL REACTOR STRATEGY FOR MANAGING PASTORAL PROPERTIES

Joe Breen and Mark Stafford Smith

CSIRO Sustainable Ecosystems, Heath Road, Alice Springs, NT 0870

BACKGROUND

For decades pastoralists and researchers have been trying to find better ways of matching stock numbers to rangeland conditions, where rainfall and grass production are more variable and less predictable than agricultural areas of Australia. This paper reports on the continuous development of a model for simulating cattle production in the arid zone. We aim to create and test simple strategies that reproduce realistic management decisions when run over simulations spanning large time periods. We can then use these strategies to better understand what impacts changes to a property's running conditions (eg. animal prices, transaction costs, weather and weeds) are likely to have on production, cash flow and impact on the land. This study builds on the RISKHerd (Stafford Smith *et al.* 2001) modelling study.

Previous studies focused on two representative strategies, *Reactor* (adjusting stock numbers to suit the amount of feed available) and *Constant* (keeping a constant level of stock on the property at all times). Although *Reactor* matches stock numbers to rangeland conditions, it is not always practicable and transaction costs could make it a less desirable option. Reacting perfectly in the variable climate of the rangelands requires extreme stock adjustments in some years. Making large stock adjustments just before an unanticipated good or bad year can cause high financial losses. Large stock reductions can limit the herd's ability to recover numbers within an acceptable time frame, forcing the producer to buy in breeding stock. In practice pastoralists do not use such extreme strategies as pure *Reactor* or *Constant.*

To better match reality we created a new strategy based on *Reactor*. *Proportional Reactor* also matches stock numbers to available feed but reduces the reaction that this matching dictates, cutting down on the transaction costs, reducing the impact on the herd and dampening some of the extreme responses arising from *Reactor*. After making regular sales and purchases the producer uses a utilisation target of available feed to determine how many extra animals to buy or sell to match their target. The producer then applies their responsiveness (the proportion which they react to their available feed) to these sales or purchases. The feed utilisation target and the responsiveness are worked out by repeatedly running the property scenario with various management targets to find the optimum cash flow. This is a formalisation of the reality that many producers who vary their stock numbers over time dampen these buying and selling decisions according to their perceptions of risk. Our study explores whether this approach improves on the simplistic *Constant* and *Reactor* strategies.

APPROACH

The purpose of the study is to explore the benefits of *Proportional Reactor*, and examine how different pricing regimes and changing natural conditions affect responsiveness. This study uses the same buying and selling set-up as used with the *Reactor* strategy but with the added responsiveness limiting the extra sales and purchases. To gain a better understanding of responsiveness the producer's target utilisation has been kept constant. Due to time limitations on running the optimisation, the buying and selling rules are maintained as they are for the original property setup and are not recreated to suit the changing conditions. This may not produce the financial optimum, however it should demonstrate the benefits of *Proportional Reactor.*

MODELS

The program GRASP (McKeon *et al.* 1990) is used to simulate pasture growth on the property. The growth data from GRASP are input into the HerdEcon model (Stafford Smith and Foran 1988).

HerdEcon is a livestock management program originally designed to help producers manage their properties and to run simple “what if” simulations based on their past records. A cut back version, for faster simulations, was created which determines the growth, reproduction and death rate of animals using a series of animal growth equations created from historical data (Stafford Smith *et al.* 2001).

To get the best setup for each property we created an optimisation program within Microsoft Excel based on an evolutionary strategy algorithm (Schwefel 1981). The algorithm takes a starting point of management targets and limits within which these targets can move. It then selects a series of new starting points and runs these through the HerdEcon model, collecting the results (in this case cash flow). These results are used to create a new series of starting points. This process continues until the incremental improvements in results are within set limits. These limits are set so as to get sensible results from the optimiser within a reasonable time frame. The starting point with the best result is then rerun to get the complete set of outcomes (including cash flow, animal numbers and sales statistics) from the property.

To examine the effect that changes in natural conditions have on the producer’s optimum behaviour the following steps were taken. First the real 108-year climate sequence was artificially modified to create climates that were more and less variable but produced the same seasonal average. Secondly the climate sequence was changed to move the average up and down, maintaining variability, as a substitute for changes that affect productivity, such as the impact of weeds or different soils. This is possible due to the way the HerdEcon model is set up. Weather data are used as an input to the GRASP program, which generates a productivity measure that in turn feeds into HerdEcon.

RESULTS

Proportional Reactor simulates a more realistic management strategy than others previously explored. It responds as expected to changing prices (it is worth being more responsive as prices improve) but did not respond intuitively to changing climate variability. We found that as the financial conditions became more favourable to the producer, his responsiveness increased. Change in responsiveness was small until the price changes approached 10%. With extremely favourable conditions the responsiveness was at 100%, equivalent to the *Reactor* strategy. When the financial conditions were approaching their worst, responsiveness was reduced to around 20%.

To get the full benefits of *Proportional Reactor*, utilisation targets should be changed as the weather or productivity changes. When utilisation was unchanged, responsiveness moved to 100% as the weather and productivity changed in either direction. There was no significant change until the productivity change became very large. As weather variability increased (and the producer can be less certain of the rain he will get) and utilisation was allowed to change, responsiveness increased to 100%. Under this scenario, utilisation decreased (causing a smaller herd to be kept on the property). When the variability of weather decreased, responsiveness remained constant while the utilisation target increased.

REFERENCES

McKeon, G.M., Day, K.A., Howden, S.M., Mott, J.J., Orr, D.M., Scattini, W.J. and Weston, E.J. (1990). Northern Australian savannas: management for pastoral production. *J Biogeogr.* 17: 355–72.

Schwefel, H.P. (1981). *Numerical Optimization of Computer Models.* Wiley, Chichester UK, 389pp.

Stafford Smith, M., Breen, J. and Cross, J. (2001). The spreadsheet version of Herd-Econ: coding, inputs and enterprise descriptions for the RISKHerd and Oceans-to-Farms projects. RISKHerd Project Report No.3, CSIRO Alice Springs. 77pp.

Stafford Smith, D.M. and Foran, B.D. (1988). Strategic decisions in pastoral management. *Aust. Rangel. J.* 10: 82–95.

GRAZING LAND MANAGEMENT IN CENTRAL AUSTRALIA, WHERE TO FROM HERE?

A. Johnson

Centralian Land Management Association, PO Box 2534, Alice Springs, NT 0871

ABSTRACT

As the impacts of grazing on the rangeland environment are increasingly being scrutinised by the wider community, the central Australian beef industry has an opportunity to review current management systems, and identify land management priorities for the future. This paper provides a background to the industry and outlines the future opportunities and challenges faced by pastoralists in the arid rangelands of central Australia.

INTRODUCTION

Pastoral leasehold land covers over 40% of central Australia, and beef production is the second largest industry to tourism. Alice Springs is the regional centre for most properties, including pastoral leases in northern South Australia. The grazing system relies mostly on native pastures, and there are several hundred pasture species that grow in the Alice region. Pasture growth and composition is highly variable and is dependent on a complex interaction of many factors, including timing and intensity of rainfall, and land type. High climate variability is the most influential and challenging factor in managing pastures and grazing.

Pastoral leases range in size, but the average property is around 3,500 sq km. The industry relies on numerous different market opportunities for turning off livestock and the region supports both *Bos taurus* and *Bos indicus* cattle breeds. Grazing systems in central Australia are extensive, and require very few inputs. The arid climate means there are few parasitic or disease related problems associated with livestock management, and low humidity allows standing pasture growth to be reserved without significant deterioration. Most properties are virtually chemical free, which provides a potential market advantage for beef producers. These markets are not currently utilised to potential, largely due to consumer and economic forces.

LAND MANAGEMENT ISSUES – THE NUTS AND BOLTS

There are numerous external and internal forces and issues that influence the way in which the pastoral community is able to respond to, and manage, land condition. Some of the major implications and factors influencing sustainable grazing management are included in Table 1.

Table 1. Major factors influencing grazing land management in central Australia.

Issue	Impact
Feral animals	Competition with livestock for available pasture, uncontrolled grazing
Exotic weeds	Competition with native plants, change in fire regimes, threat to native habitat
Woody weeds	Shrub encroachment, change in landscape ecology, competition with pasture
Uncontrolled wildfires	Loss of available forage and ground cover, change in landscape ecology, damage to, and loss of, infrastructure
Unpredictable climatic conditions	Risk of drought – loss of cover and species, overgrazing
Soil erosion	Loss of topsoil, land degradation, poor water infiltration
Decrease in species diversity	Loss of palatable pasture species, loss of biodiversity and decreased rate of production, threats to native flora and fauna
Increase in interest rates & overhead costs	Reduced ability to invest in, and spend time on, land management activities
Market forces	Influences ability to turn-off livestock and maintain a profitable business

FUTURE OPPORTUNITIES FOR GRAZING LAND MANAGEMENT IN CENTRAL AUSTRALIA

The Centralian Land Management Association (CLMA) is actively involved with developing and promoting sustainable grazing management practices for present and future generations of beef producers in the Alice Springs region. CLMA enjoys a membership of over 80% of cattle stations in the region, and the organisation has a strong history of establishing sound relationships with and between land managers, research agencies, community groups and conservation organisations. As the pastoral community becomes more involved with the use of electronic communication and embraces the tools and information support services of the World Wide Web and computer software, land management is taking on a new level. Access to digital data, maps and remote sensing images has raised awareness of property and regional scale issues and systems, and enables managers to engage in a holistic management approach.

The direction in which the industry and the CLMA is now moving is to marry existing knowledge and land management experience with innovative technology and education programs. Combining historic data and local experience with technology will improve and develop better decision support systems for producers. In addition to grass roots and on-ground support (eg. access to and provision of local native pasture seed, weed management advice etc.) the CLMA is now engaged with developing projects and partnerships to raise the level of awareness and understanding of ecological and economical principles of grazing management in arid rangelands.

Current projects being implemented and developed by the CLMA include:

- Environmental Management Systems (EMS) project.
- Grazing Land Management (GLM) education program.
- Community education and awareness – increasing awareness of the beef industry's involvement with natural resource management.
- Regional natural resource management plans (initiated by the Australian, State and Territory Governments). CLMA is involved in consultation with beef producers and community groups to contribute to NRM planning processes for regions covering central Australia.

SUMMARY

The future of sustainable grazing land management in central Australia is not solely dependent on producers. Sound grazing management will require the input, experience, and committed investment from government bodies, research agencies, conservation groups and the general public. The ability of producers to be proactively involved with natural resource management will be dependent on:

- Maintenance and development of strong communication networks;
- Establishment and maintenance of sound relationships between key stakeholder groups; and
- The encouragement of leaders in the industry to find new markets and opportunities to make managing grazing land both sustainable and economical.

A CREATIVITY PARADIGM IN RANGELANDS RESEARCH

Paul Makeham and Bill Dunstone

Creative Industries Faculty, Queensland University of Technology Kelvin Grove, Qld, 4059
Division of Humanities, Curtin University of Technology, GPO Box1987, Perth WA 6845

In order for outback Australia to sustain itself, a balance has to be struck between seemingly incompatible demands: economic, social, ecological. These demands can act as barriers, polarising opinion, creating conflict, and impeding productive land management, economic development and social cohesion. History can be a barrier at times: binding people to habit; making them fear change; and blurring boundaries between conservation and conservatism. Conversely, these same demands can co-exist in creative tension. What is at stake is the capacity to manage change.

The capacity to cope with change is a creative skill, and the importance of creativity as a management tool is increasingly apparent in a range of contexts. Through creativity, for instance, we can manage barriers that traditionally separate sciences and humanities. Creativity and scientific method approach each other whenever the researcher takes the role of 'participant-conceptualiser' in an ecology of system, in which the researcher's perception of the system 'is critical to the system' itself (Ison *et al.* 2000). Creativity allows us to see relationships which haven't been apparent; and creative practice is a way of giving life and shape to these relationships in communities.

There is an increased understanding, at government policy making level and among researchers in fields as traditionally diverse as agriculture and community cultural development (CCD), of 'the interrelatedness of social, cultural, economic and environmental factors in [our] understanding of wellbeing within a community context' (Mills 2003). Researchers from Agriculture WA, the Centre for the Management of Arid Environments (CMAE), Kalgoorlie-Boulder WA, and the Live Events Research Network (LERN), based at the Flinders University of South Australia, are discussing a joint project to integrate CCD principles and practice into the conceptualisation, conduct and delivery of arid rangelands research. In effect, these researchers have set themselves the task of conceptualising, designing and managing a creativity paradigm in rangelands research.

The aim of this integrated approach is to enhance the sustainability of remote rural communities through 'natural resources management, economic revitalisation, community strengthening, active citizenship, diversity and inclusion, [and] health and wellbeing' (Mills 2003). The intention is to integrate methodological concepts and design from the two research fields, in order to triangulate a third, creative paradigm in arid environment research and development. This creative paradigm will entail a 'transformational' approach, a re-thinking of the ways in which urban oriented CCD theory and practice can relate to quantifiable economic, social and ecological outcomes in remote rural communities. The transformational approach equally entails enquiry into the ways in which scientific research can be more effective, ethical and epistemologically aware in its theorisation, conceptualisation, design, management and delivery processes.

The starting point of the joint project is pragmatic. There is a perceived need at CMAE and Agriculture WA to enhance the 'people' factor in agricultural research in Land Care Districts for which these bodies have responsibility. It is perceived that traditional models of 'knowledge transfer' from 'objective' researchers to recipient communities tend to be hierarchical and hegemonic in practice. Standard 'transfer of technology' (ToT) models generate conceptual and cultural 'blind spots' and power imbalances that inhibit the 'connectedness' between community and researchers that gives meaning to useful, efficient practice in the first place (Ison *et al.* 2000).

The practical objective is then to link creative and scientific methodologies that will 're-connect' researchers and community stakeholders in innovative 'learning networks' that generate social capital. Rural stakeholder communities will be engaged from the outset in research conceptualisation, design, management, assessment and evaluation. The desired short term outcome is to enhance the application of rangelands agricultural research in the designated Land Care Districts. The long term aim is to enhance the social, cultural, economic and environmental viability (that is, the health and wellbeing) of the rural community within an ecology of systems.

It is envisaged that the creative methodologies implemented will incorporate strategies and perspectives which are performative in nature, even though they might not include conventional artistic or community performances as such. Performativity is a broad-ranging and inclusive paradigm, predicated on the notion that 'human culture is in large measure performative, that is, activity consciously carried out and presented to others in order to have some effect on them' (Carlson 2001). As such, we propose a type of praxis in which performative elements (exchange, display, dialogue, design, enactment) can provide new and creative ways of understanding and addressing some of the challenges confronting rural communities. As a starting point, we will apply performativity analysis to current power relations between rural stakeholders, Agriculture WA, CMAE and CCD researchers.

The theorised practical activity (praxis) that emerges from this research collaboration will be responsive to, and determined by, the lived experience of communities of interest. Joseph Dunne describes praxis as 'a type of human engagement that is embedded within a tradition of communally shared understandings and values, that remains vitally connected to people's life experience, that finds expression in their ordinary linguistic usage, and that, rather than being a means through which they achieve outcomes separate from themselves, is a kind of enactment through which they constitute themselves as persons in a historical community' (Dunne 1993). That said, the project partners are keen to avoid a naïve kind of populism in their approach. 'The community' here is engaged, in the first instance at least, through formal structures of representation, rather than through some form of unmediated appeal to 'the people'.

Rangeland communities can creatively manage the challenges confronting them. Transitions from isolation to cohesion, disenfranchisement to action, separateness to community, are enabled when people 'own' their stories, when they develop shared languages and symbols, and when they share risks and collaborate creatively on solutions. Through such processes, people can approach a shared understanding of how their community works. This understanding can ground their perception of community issues; and it can ground the formulation of research. Individuals can affirm their experience, while learning to value differences within their community. We suggest that benefits arising from community cultural development projects, in which 'ordinary people' are central players, are achievable by rangeland communities and researchers alike.

REFERENCES

Carlson, M. (2001). Theatre and Performance at a Time of Shifting Disciplines. *Theatre Research International,* 26: 136-144.

Dunne, J (1993). *Back to the Rough Ground: 'Phronesis' and 'Techne' in Modern Philosophy and in Aristotle.* Notre Dame, IN: U Notre Dame Press.

Ison, R.L. and Russell, D.B, eds. (2000). *Agricultural Extension and Rural Development: Breaking out of Conventions. A Second-Order Systems Perspective.* Cambridge UK: CUP.

Mills, D. (2003). Art and wellbeing. *Artwork Magazine,* 57: 18-21.

CONNECTED REGIONAL, RURAL AND REMOTE COMMUNITIES: A CENTRAL AUSTRALIAN SCOPING STUDY

Yiheyis Maru, Vanessa Chewings and Margaret Friedel

CSIRO Sustainable Ecosystems, Centre for Arid Zone Research,
PO Box 2111, Alice Springs, NT 0871

INTRODUCTION

Advances in information and communication technologies (ICT) are increasingly enabling improvement in public and private service deliveries to communities. Various types of communities (communities of location, practice and interest) are also using ICT to share experiences, communicate aspirations and participate in relevant programs. This study was part of a wider scoping project called 'Connected Communities', which explored the role of ICT in the articulation of community aspirations and the delivery of services by various organisations to regional, rural and remote communities. The project had case study communities in the Northern Territory, New South Wales and Queensland. The project included three major tasks:

1. Gaining an understanding of ICT in the context of remote, rural and regional communities.
2. Gaining an understanding of community aspirations.
3. Undertaking a workshop with community, industry and government to discuss options for ICT projects, select preferred directions, and secure support.

This paper presents a case study involving people from the Natural Resource Management (NRM) community in Alice Springs, and focuses largely on outcomes of Task 2.

APPROACH

The initial task in the Connected Communities project was to undertake a general review of the role of ICT in regional, rural and remote communities, using web-based searching, literature, and monitoring of discussion groups. From this review the role of ICT in facilitating community demands and aspirations for NRM emerged as the focus for the Alice Springs case study.

To undertake Task 2, we interviewed 17 people from different government, non-government and private NRM-related agencies through semi-structured discussions. NRM agencies in Alice Springs play a key role in identifying NRM-related aspirations and needs of surrounding communities and enterprises, and the delivery of services to these communities. These agencies are also in a position to assess the feasibility of using advances in ICT in regional NRM planning and implementation processes. Stakeholders of these organizations include pastoral, indigenous, government, mining and public interests and private landholders.

Interviews were analysed for common themes, a synthesis document was circulated to interviewees and their feedback was obtained to ensure interpretations were correct.

FINDINGS

Five main activities which ICT could facilitate emerged from the Task 2 interviews:

- Regional NRM planning in the Alice Spring region, where coordination is a challenge given the sparse population density and remoteness of communities.
- Networking NRM agencies to reinvigorate an existing informal email network of NRM officers for various purposes such as facilitating the regional planning process and promoting inter-organisation cooperation.

- Making information from diverse collaborating agencies accessible and dynamic through appropriate data sharing platforms and timely updates.
- Developing coordinated and customised information delivery to satisfy information demands of overlapping client bases of the various NRM agencies.
- Capacity building to enable local governments, private agencies and communities to participate in various NRM activities. Visual and interactive communication media were suggested for improved community participation in NRM.

For instance, regarding the fourth activity, ICT has the potential to substantially improve coordinated delivery of existing services involving several different agencies. Coordinated information delivery could help to:

- Reach beyond traditional client groups (e.g. N.T. Bushfires Council could distribute fire information to Aboriginal landholders as well as pastoralists),
- Engage clients' interest by delivering different but relevant information as an ongoing activity rather than being event-driven,
- Promote cooperation of agencies and officers at different levels, and
- Value-add to existing ICT and other infrastructure found in different organisations.

Interview participants also identified institutional and technology-related barriers and constraints as well as enablers. The key institutional barrier that could limit the potential use of ICT was weak inter-agency relations. Other barriers included high turnover of ICT skilled personnel and slow adoption rate of new ICT technologies. Potential enablers included existing interpersonal relationships among officers involved in NRM activities in different agencies, and their complementary resources that make value adding possible.

Participants raised various other issues that may need to be considered in the development of any future activities. For instance, interviewees noted that the remoteness of communities in the case study area indicates a substantial role for ICT in the delivery of customised services. However, the cost of delivery and the capacity of clients to purchase services given widespread socio-economic disadvantage of remote communities meant that a market model may not be appropriate. Sparse client density and low short term economic returns associated with demands of natural resources management compound the problem.

In addition, the use of advanced technology such as satellite mobile phones was noted as possibly contributing to a loss of social cohesion in pastoral communities, through the reduction of social events like bush races, and local group interactions. The possible negative impacts of expanding the use of advanced ICT into regional, rural and remote communities needs to be considered, along with the potential advantages.

CONCLUSION

The research process was adaptive and participatory where the project direction was determined by local context and active involvement of research participants. A key finding of the case study was that better interpersonal and interagency communication was as important as any technical improvement in ICT for the delivery of NRM outcomes.

A THREE STEP MODEL TO PRACTICE CHANGE

I.H. Simpson [1], *W.K. Mason* [1] *and R.D.B. Whalley* [2]

[1] PO Box E9, East Orange NSW 2800. e-mail: <isimpson@ix.net.au>
[2] Centre for Ecology, Evolution and Systematics, Botany, UNE, Armidale NSW 2351

Change is going on in everyone's life. While some change is forced on us, most occurs because we decide to make a change to achieve a different outcome. During the Sustainable Grazing Systems (SGS) Program 1996 – 2002, a Practice Change Model (Fig. 1) was developed from extension theory and practical experience of producers, researchers and extension practitioners (Nicholson *et al.* 2003). The SGS program was spectacularly successful in supporting practice change. Over 8,000 producers made changes they anticipated would yield both financial (78%) and sustainability (81%) benefits (Allan *et al.* 2003).

Figure 1. Practice Change Model – making change is simply a three-step process.

Motivation stage – creating a reason or desire for wanting to change practices
Motivation is created by the anticipation of a possible gain (the strongest desire) or a potential loss, and is an essential ingredient of every change. Genuine motivation is essential if interest and commitment are to be sustained – even small difficulties at this early stage can result in withdrawal of involvement.

Exploration & trialing stage – planning what changes to make and how to make them
This stage involves working towards a solution through a series of logical steps that include: seeking a range of possible solutions that align with vision and goals; weighing up options; skills development; gaining support from an 'inner circle'; and, where possible testing changes on a small scale.

Farm practice change stage – making the change across the farm
The rate of adoption from a trial to whole of farm will vary depending on whether the practice meets expectations and the capacity (skills, knowledge and financial) to implement change. Wide scale adoption often leads to new questions that if not answered effectively can lead to scaling back or abandonment and the investment lost. Peer recognition, personal support and encouragement and confidence are needed to maintain commitment, especially if results are below or slower than expected.

WHO BENEFITS

The practice change model helps:

- Producers work through the issues as they identify an opportunity to change, and explore the implications of making the change, before finally building a new practice into their system;

- Those designing tools, products or programs that aim to achieve practice change on properties; and
- Extension practitioners identify the particular requirements of producers at the various stages of the practice change cycle, and therefore how best to assist producers move through the cycle.

TOOLS AND PRODUCTS CHECKLIST

Appropriate, well-designed tools and products can greatly enhance the awareness, motivation, confidence and adoption of new practices. A series of check lists has been designed (Mason *et al.* 2003) to assist in the development of a tool or product created to support a practice change. **Part A** consists of a series of questions to explore/understand the practice change. **Part B** provides questions to assist with targeting the tool or product towards motivation, exploration and trialing, or to supporting the farm practice change. The number of positive responses to the questions in the checklist will increase the probability of success.

Part A – Sample of the questions to explore and describe the practice change

1. What is the desired farm practice change and the target market?
2. Is there strong 'evidence' that adoption of the desired practice change will reduce the negative impacts of the current practice and lead to a possible gain?
3. Is the negative impact of the current practice occurring rapidly or slowly?
4. What is the producer's impression about the current practice once the tool or product is used?
5. Describe the goals a producer will require to be interested in this tool?
6. Is the alternative practice change simple to adopt and with minimum impacts (consequences) to other parts of the farm operation and is it easy to reverse (if desired) and cheap to implement?
7. What intellectual and social capacity is required to adopt the practice across the whole farm?

PART B – Sample questions to match tools to the stages of practice change

Motivation stage

1. Is training required before the tool or product can be used or the results implemented?
2. Can the tool or product be linked to locally relevant benchmarks?
3. Can the tool or product be distributed and demonstrated by a range of people?

Exploration and Trialing stage

1. Will the tool or product help demonstrate the impact of adopting a new practice within three years and will it help build understanding of the principles that underpin the practice change?
2. Does the tool assist producers to benchmark their situation and compare with their aims/goals?
3. Does the tool or product have the flexibility to be delivered in a one-on-one situation, a group, and in a 'do it yourself' situation, and appeal to a range of learning styles?
4. Do the data from the tool or product support discussions or family dialogue?

Farm Practice Change stage

1. Does the tool or product provide re-assurance that the change is beneficial, and build/maintain confidence and commitment to farm practice change?

Networks that enable producers and people in support roles to interact and actively learn from one another in a non-threatening environment can greatly speed up the change process.

REFERENCES

Allan, C *et al* (2003). Evaluation of the impact of SGS on livestock producers and their practices. *AJEA* **43**, (SGS Special Edition) pp. 1031-1040.

Mason, W *et al* Eds (2003). *Towards Sustainable Grazing – The Professional Producer's Guide.* Meat & Livestock Australia, Sydney, pp. 119-129.

Nicholson, C. *et al* (2003). A research-extension model for encouraging the adoption of productive and sustainable practices in the high rainfall grazing areas. *AJEA* 43: (SGS Special Edition) pp. 685-694.

BESTPRAC – FOCUSING THINKING AND ACTION TO IMPROVE THE PERFORMANCE OF RANGELAND WOOL PRODUCERS

J. Squires and D. Heinjus

Rural Directions Pty Ltd, PO Box 646, Clare SA 5453

BACKGROUND

Bestprac is a group based benchmarking and continuous improvement program funded by Australian Wool Innovation and Meat and Livestock Australia. The Bestprac network started in 1998 and aims to enhance producer thinking skills, processes and techniques and provide them with a range of tools to move their business forward. There is currently a network of 26 producer groups across Queensland, New South Wales, South Australia and Western Australia.

AIMS OF BESTPRAC

By 2006, the project aims to achieve the following outcomes:

- Bestprac participants are applying management systems that lift individual profitability, environment and well being by 5%.
- Develop a confident proactive and capable innovation network involving 318 specialist wool and meat producing businesses (in high performance teams) and facilitators who exchange ideas, improvements, innovations and technologies for improving rural business profit, environment and well being.
- Have well established and productive partnerships between the innovation network and research, development and innovation services within the wool supply chain.

PROCESS

Bestprac groups generally consist of between five and seven wool producers from a local area that meet together a minimum of four times a year. A facilitator (agricultural consultant or extension officer) assists each member of the group to benchmark their business to identify strengths, weaknesses, opportunities and threats. Based on this assessment, farm projects and plans are developed to improve business performance (Fig. 1). Using a process of group discussion, a tailored skills development program is developed to provide group members with the skills, confidence and networks to implement their projects.

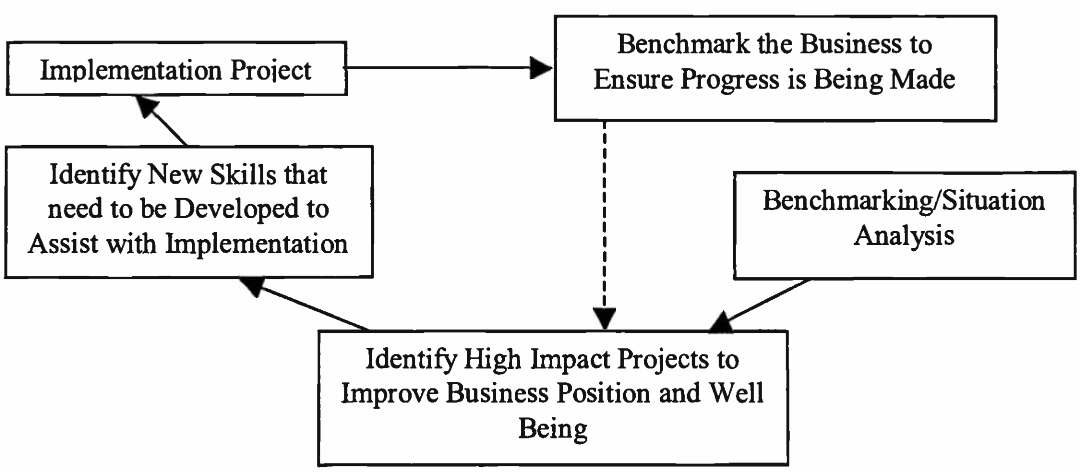


Figure 1. The Bestprac process.

The skills development program can include:

- Training sessions on technical, management, financial, resource or people issues. Examples of activities conducted by Bestprac groups include sheep breeding, animal nutrition, time management, stress management, property management and holistic grazing management.
- Field days to examine a range of issues in one day. Examples include breed diversification field days, feedlotting, merino field days, industry meat and wool days.
- Networking visits to other Bestprac groups and properties to investigate new practices and innovation.
- Visits to wool stores and meat and wool processors to better understand the market chain and opportunities for improving returns from wool and meat.

IMPACT OF DROUGHT

The 2002 drought and continuing poor seasonal conditions have placed significant pressure on rangelands businesses. In addition to confronting financial management issues, businesses have had to manage livestock and natural resource management issues. In this environment, members of Bestprac groups have benefited from the group support network by:

- Maintaining a positive outlook;
- Identifying opportunities for financial support;
- Providing a reference group to assist with difficult decision making; and
- Providing opportunities to agist stock on properties benefiting from local rainfall.

RESULTS TO DATE

Bestprac has helped to build confidence, sharpen business planning skills and brought positive changes in knowledge, attitude and skills. Groups have been encouraged to think positively in tough conditions, take ownership for improving business performance and in a supported environment, take on projects that have a high chance of improving business performance and resource management. Feedback from producers shows that up to 80% of Bestprac group members have made changes to on-farm management practices. In addition, nearly 15% have reported increased profits as a direct result of involvement with the program.

Contacts and group status for the current round of Bestprac are:

- National Bestprac coordinator is David Heinjus – Ph: 08 8842 1103.
- South Australia has ten groups operating. Contact person is Jennifer Repper – Ph: 08 8535 6400.
- New South Wales has 12 groups operating. Contact person is Mark Gardner – Ph: 02 6884 2242.
- Western Australia has five groups operating. Contact person is Greg Brennan – Ph: 08 9088 6033.
- Queensland has eight groups operating. Contact person is Lloyd Dunlop – Ph: 07 4671 6708.

LOCAL PROJECTS FOR REGIONAL SUSTAINABILITY

S. Van Wyngaarden [1], *H. Turner* [2], *A. Maskew* [3] *and M. Jukes* [4]

[1] Centre for Management of Arid Environments, Locked Bag 22, Kalgoorlie WA 6433
[2] Department of Agriculture, PO Box 1618, Karratha, WA 6714
[3] Department of Agriculture, PO Box 522, Carnarvon WA 6701
[4] Department of Agriculture, PO Box 278, Derby WA 6728

Sustainability is clearly the guiding principle of Natural Resource Management in Australia. All the regions in Australia require a **Natural Resource Management (NRM) Strategy** which sets targets and priorities for investment of Natural Heritage Trust 2 (NHT2) funding. The Western Australian NRM Council defines Natural Resource Management as:

> *Ecologically sustainable management of the land, water, air and biodiversity resources of the State for the benefit of existing and future generations, and for the maintenance of life support capability of the biosphere. It does not include mineral resources but includes coastal and marine resources up to the State three nautical mile boundary.*

NHT2 focuses on four key program areas; Sustainable Land-use, Rivercare, Coastcare and Biodiversity, however this poster spotlights the Sustainable Land-Use Program in the Rangelands region of Western Australia. The sustainable land-use program (also known as Landcare) will invest in activities that will contribute to reversing land degradation and promoting sustainable agriculture.

The Rangelands NHT region of WA covers 87% of Western Australia. It includes a diverse range of relatively intact ecosystems including e.g. tussock grasslands, shrublands, woodlands and monsoonal forest. Pastoralists are the primary managers of nearly half of the Western Australian rangelands; the remainder is managed as unallocated crown land (UCL), Aboriginal Communities and the Department of Conservation and Land Management (CALM) managed properties such as nature reserves. As part of the development of an accredited NRM Strategy, the Western Australian Rangelands Coordinating Group (the group responsible for preparing the Rangeland NRM Strategy) has divided the rangelands into four administrative sub-regions – the Kimberley, Pilbara, Gascoyne-Murchison and Goldfields-Nullarbor.

The sub-regions contain Land Conservation District Committees (LCDC). LCDC membership is mostly held by pastoralists along with representatives from mining, local government and the Department of Agriculture. LCDCs are a mechanism for getting sustainable resource use happening at a local and individual level.

The pastoral natural resource value of a land unit can be quantified using the long-term stock capability rating developed by Holm *et al.* (1995). This guide for stocking rates is based on soil, vegetation and effective rainfall attributes (rangeland condition). The derived rating indicates the long term sustainable stocking density of a particular land unit in a particular range condition.

Pastoralists through the LCDCs are managing projects funded by NHT1 and NHT2 at a local level to meet sustainable land-use targets. Some of these projects are:

HARVESTING NATIVE GRASSES ON THE NULLARBOR

The Nullarbor-Eyre Highway LCD wanted to know if the native grasses that grow after significant rainfall could be harvested, and if it would be a good fodder for sheep and cattle. The answer is "yes". Through a Natural Heritage Trust 1 project grant, a contract harvester made 410 bales weighing an average 275 kg off 40 hectares of land. Although the process was not optimal (the grasses had set seed and begun to dry off at the time of harvest) the bales were still a big hit with both cattle and sheep and provided a satisfactory maintenance diet. An additional benefit of local production from native pastures is that producers know it does not contain new weeds and that it is chemical free. With approximately 30% (17,400 sq km) of the Nullarbor covered in native grasses, there is potential for a significant and sustainable production regime to be implemented.

MESQUITE CONTROL IN THE PILBARA

Developing and implementing best-practice management for fire-tolerant mesquite in Australia is a cross regional project evaluating several control methods to determine the optimal approach. A major goal of the project is to address critical knowledge gaps (e.g. can fire can be used to manage fire-tolerant mesquite in semi-arid regions?), improving kill rates for strategic infestations, developing and identifying areas within a catchment or region at greatest risk of mesquite invasion, and predicting the long term impact of the available biological control agents. The project will also develop and test new ways of managing containment zones for pastoralists to control spread of infestations.

TOTAL GRAZING MANAGEMENT

Total Grazing Management (TGM) is aimed at increasing the productivity and sustainability of stations in the Western Australian rangelands. In WA rangelands, the primary tool used for TGM is permanent trapyards at water points. These trapyards control access to and egress from watering points, thus giving managers a high level of control over station animals. TGM allows the manager to implement grazing management strategies, such as rotational grazing, by greatly reducing mustering costs. Through better animal handling technology and infrastructure, station profits and range condition can improve (Underwood 2002).

WEST KIMBERLEY NOOGOORA BURR PROJECT

Weed and pest infestations have been a major concern for land managers in the Kimberley sub-region over the years. This is partly due to the quarantine issues arising from border/customs efforts, along with the ideal climate for weed establishment and transportation (high rainfall, many river systems to infest). As a result many projects have been developed and implemented to address these issues. One such accredited NHT2 project currently being piloted is the 'Developing Capacity to Manage noogoora burr Infestations in the West Kimberley WA'. This project undertakes surveys and mapping to identify areas of noogoora burr infestation and targets high risk areas for chemical and physical control action. The project will reduce the incidence of noogoora burr in the Fitzroy River catchment area and provide community education and capacity directed at reducing the spread and infestation of this significant weed. Expected outcomes of the project will include the production of maps of infestation areas according to threat levels, improved community skills and commitment to managing weeds, a healthier, more accessible catchment area and reduced burr impacts on livestock facilitating lowered production costs to pastoralists.

The challenge now is to continue the developing project activities that appeal to funding agencies while addressing the immediate needs of land managers within a framework of planning for sustainable use.

REFERENCE

Holm, A.McR., O'Connor, R., Foster, I., Stevens, M. and Beeston, G. (1995). *Regional Relativities of Sustainable Pastoral Sheep Production in Western Australia.* Pastoral Wool Industry Task Force and Wool Strategy Task Force.

Underwood, C. (2002). *Total Grazing Management Field Guide: Self mustering systems for cattle, sheep and goats.* Department of Agriculture Western Australia Bulletin No. 4547.

Business Systems
(Poster Group Three)

INNOVATION IN THE DESERT: TELLING THE STORIES

Vanessa Chewings [1] and Mike Crowe [2]

[1] CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs, NT. 0871
Ph 08 89507127, fax 08 89507187. email Vanessa.Chewings@csiro.au
[2] Desert Knowledge Australia, PO Box 2114, Alice Springs NT 0871
Ph 08 89515219, Mobile: 0411 114266, Fax 08 8951 5164, mike.crowe@nt.gov.au

INTRODUCTION

Although small businesses are the lifeblood of desert Australia, there is a lack of readily accessible information on the success factors and special needs of these enterprises. A pilot project 'Innovation in the desert: telling the stories' aimed to raise awareness by providing a forum for operators of successful small and medium enterprises from desert areas to tell their stories of best practice using video, audio and written material on the project website. The project was undertaken in 2003 by CSIRO with Desert Knowledge Australia. A website, promoting project outcomes, is accessible to a wide audience, including our main target groups which are businesses across inland Australia, the education sector and the general public in desert Australia.

INFORMATION RESOURCES

The Desert Knowledge Australia network was used to identify potential stories and to ensure that the material produced during the project would be of value to target groups. This was done through a regional representative group which regularly holds meetings by video conference and actively pursues topics of common interest across the geographical regions of Kalgoorlie, Broken Hill, Alice Springs, Pt. Augusta, Coober Pedy and Mt Isa. An enthusiastic steering committee was established for the pilot project which included representatives from this network.

There are numerous sources of generic information available on how to establish and maintain a business such as Commonwealth and State Government websites. Newsletters, e.g. 'Getting down to business' from the Department of Industry, Tourism and Resources, often highlight new or innovative enterprises. However this material does not address the particular challenges of operating a SME in desert Australia. The steering committee was particularly keen to know what issues concerned business operators in desert Australia and where businesses sought advice. Some of the questions we put to the profiled businesses included: What are some of the challenges you face? How do you address these challenges? How do you address staffing, isolation, technology and social and economic issues? What are some of the key factors in your success? Are there special factors in building a business in desert Australia? How do you recognise opportunities? When you have a small team and a product, how can you keep the team going? We asked a number of business operators during this pilot project where they sought advice. Most nominated personal, local contacts, such as Chambers of Commerce, banks, accountants and people in government agencies as preferred sources for information. Operators consistently indicated that resource material needed to be concise, relevant and presented in accessible forms. They also valued information which came directly from other business operators, whether written or oral, more highly than material which had been 'processed' by intermediaries.

PROFILED BUSINESSES

As there was a large number of potential showcase businesses and only two could be profiled in the pilot project, the steering committee decided that it was appropriate to link the selection process to another credible assessment mechanism. Telstra Small Business Awards were therefore approached and the list of their finalists for 2002 and 2003 was used for the selection process. These businesses had already been through a rigorous judging process. The first business profiled was Littlefish Pangaea, an Alice Springs-based small business which develops easy-to-understand financial reporting material tailored to remote Aboriginal communities in the Northern Territory and Western Australia. In the audio interview Hugh Lovesy talks about the special requirements for doing business with Aboriginal communities. The video clip features a representative from the Urapuntja Health Clinic, situated 300km north east of Alice Springs demonstrating how the clinic uses the material developed by Littlefish Pangaea.

The second business profiled was Diab Engineering, a business based in Geraldton, W.A., which serves the mining industry in remote locations and works in direct competition with city-based operators. In this profile David Payne talks about how the partners built the business by seeking new markets and developing efficient ways to move machinery and people over large distances. David also talks about the value of training local youth.

As well as the businesses profiled and members of the steering committee, a number of local small business operators were involved in the production of the information material through website design, acquiring video footage, audio interviews and the written material.

WEBSITE

The information is hosted on the Desert Knowledge Australia website and contains business profiles as well as links to resources and desert organisations: URL www.desertknowledge.com.au/innovation.

The profiles on individual businesses include video, audio and written material. There are few graphics on the site, to minimise the time needed to load pages. The audio and video clips are approximately two minutes long and are available in two formats, one suitable for dialup viewing and the other for broadband. On Demand streaming was setup for the audio and video content for an initial period of six months. Transcripts of all audio and video material are also included on the site for visitors with slow internet connections.

Information on visitor behaviour and preferences is monitored using site statistics such as the source and duration of hits, web browsers used and referring sites. The Desert Knowledge Australia site received 18,218 hits between October 14, 2003 and March 29, 2004. Of these 2289 were to the innovations site and 21% of these hits were to the page where the video clips are located.

DISCUSSION

The site was launched by Minister Peter McGauran on October 14, 2003 and the positive signals at this time convinced us to submit another proposal for an extended project with three components: 1) to profile a further 18 businesses, 2) to conduct a trial of online tools to facilitate collaboration across geographical and organisational boundaries and 3) to provide contact information on industry specific desert businesses in areas such as horticulture, wildfood, tourism, renewable energy, housing and mining services. This component was specifically requested by members of our steering committee. The initial application was unsuccessful. However there are ongoing discussions with potential sponsors and supporters to continue the development of this project.

Our experience with the pilot project was that innovative desert businesses have interesting and informative stories to tell and are keen to share their experiences with other businesses and the wider community. We are still hopeful that sufficient resources will be found to include more businesses on the website, although w may need to rethink how we 'sell' the message of innovation.

ACKNOWLEDGEMENTS

The pilot project was funded by the Commonwealth Department of Industry, Tourism and Resources as part of its National Innovation Awareness Strategy. We thank members of the project steering committee for their enthusiasm, support and assistance: Margaret Friedel (CSIRO), Sharon Hocking (Competent Services), Damien Ryan (Alice Springs Camera Centre), Paul Venturin (Independent Grocers), Annaliese Walster (Goldfields Esperance Development Commission).

Indigenous Land Management
(Poster Group Four)

THE INDIGENOUS PASTORAL PROJECT: PEOPLE ACHIEVING DEVELOPMENT, CONSERVATION AND PEOPLE OUTCOMES

M. Ashley, A. Hudd, G. Richardson and Alister Trier

Northern Land Council, PO Box 396 Katherine NT 0851
NT Department of Business, Industry and Resource Development, PO Box 1346, Katherine NT 0851

The Indigenous Pastoral Project (IPP) was developed during 2003 to improve land management and pastoral outcomes for Aboriginal people in the rangeland regions of the Top End of the Northern Territory. Currently Aboriginal people own and manage approximately 65,000 sq km of rangeland areas within the Northern Land Council (NLC) region. The IPP will assist Traditional Owners achieve land management outcomes by establishing sustainable economic enterprises on Aboriginal owned pastoral stations. The IPP takes a 'people first' approach, incorporating capacity building and training programs on topics such as land and financial management and corporate governance.

The IPP will use multiple land use planning to identify compatible land use options and develop economic activities. These enterprises could then contribute to the cost of land management activities such as weed and feral animal control as well as cultural site protection and fire management. It is anticipated that the use of multiple land use planning will provide a mechanism to address community conflict that sometimes occurs with communal land ownership, by accommodating different land use aspirations in specific areas, culminating in a land management and development consensus. The project will use a whole-of-property approach and aims to develop Property Management Plans that address environmental protection as well as pastoral and other production.

An essential part of the IPP process is the acknowledgement of Aboriginal land ownership, emphasising the rights of Aboriginal people to drive the agenda on their own land. Involvement of Aboriginal landowners in the planning process is a fundamental aspect of the project which aims to utilise a 'people first' approach that encourages Aboriginal landowners to be pro-active in determining the level and type of enterprise development on their land.

The IPP is a joint project incorporating staff and funds from the NLC, the Northern Territory Department of Business, Industry and Resource Development (DBIRD), the Indigenous Land Corporation (ILC), and "in-kind" support from the Department of Infrastructure, Planning and Environment (DIPE). Each agency provides specialist skills: the NLC provides anthropological advice and conflict resolution skills, NT DBIRD provides technical pastoral production support and the ILC provides project management support, and operational funding requirements.

To date the project has been successful in a number of areas:

- It has supported Traditional Owners to resolve long-standing conflict and commence pastoral and land management activities in the western Victoria River District.
- It has facilitated partnerships between an existing Aboriginal property in the Roper Valley Region and business investors, to increase the economic and environmental sustainability of the property.
- Is working with Traditional Owners of a large property in the Gulf Region who have resolved significant conflicts and are committed to exploring multiple land use options.

These areas of Aboriginal land represent approximately 5,800 sq km in total that now have an economic base for improved land management and are contributing to the economic strengthening of Aboriginal Corporations.

FINDING TJAKURA

T. Carnegie, N. Giles, P. Davies and M. Hourihan

Ngaanyatjarra Council Land Management Unit, PMB 71, via Alice Springs, NT 0872

The Tjakura (Great Desert Skink, *Egernia kintorei*) is a large chunky lizard. They inhabit the Western Deserts, a region extending from the Tanami in the north to the Great Victoria in the south and west to the Great Sandy Desert in typical *pila* (sandplain) or *rirra* (undulating lateritic gravel downs) country that is dominated by spinifex (McAlpin 2001). They curiously construct communal burrows that are over one m deep and up to ten m in diameter (McAlpin 2001). An established burrow can house up to ten Tjakura; often an adult pair and young from the current and previous year (McAlpin 2001). Another curious feature of Tjakura behavior is the habitual urge to deposit scats in a communal latrine which, at large burrows, can cover an area of up to three sq m (McAlpin 2001). The Tjakura itself is identifiable by its unique colouring. Lizards found in the Gibson Desert are a bright orange brown on top reminiscent of the desert sands with brilliant lemon-yellow stomachs. Tjakura grow to about 440 mm total length and can weigh up to 350 gm (McAlpin 2001).

The Ngaanyatjarra Lands in Western Australia occupy an area adjacent to the Northern Territory – South Australian border, stretching from a latitude just north of Alice Springs to about 500 km north of Kalgoorlie and west about 700 kms. Tjakura are well known to some senior Aboriginal people from the Ngaanyatjarra communities of Warakurna, Patjarr and Warburton who grew up in a traditional or semi-traditional way, hunted this species and who continue to hunt and gather on their lands. It appears that Tjakura were most common around these communities and Jan Turner, Anthropologist for the Ngaanyatjarra Council Native Title Unit says they play a part in the Tjukurpa or dreamimg of this area where Tjakura Tjukurpa sites seem to be localised. However changed cultural practices, due to community living, mean that the skink is little known to the younger generations of Ngaanyatjarra people. The reduction in the transmission of cultural and traditional ecological knowledge to younger generations, and changes in cultural practices, besides resulting in a cultural deficit, may affect the long-term survival of this species in remote areas of Ngaanyatjarra Lands.

Changes in traditional land management practices since the mid twentieth century has resulted in a changed fire regime across most of the Ngaanyatjarra Lands. Except for areas around the eleven remote Ngaanyatjarra communities and well traveled roads, fire events have changed from traditional patch burning across large ranges to no burning at all or to large wildfires. The changed fire regime has meant significant habitat change for Tjakura and other species. While Tjakura are able to travel the short distances between traditional patch burns and recolonise recently burnt habitat, large fires burn huge swaths of country (McAlpin 2001). Populations at the edge of a large fire may be able to survive, but habitat within the fire zone is greatly reduced and recolonisation of the area may take many years (McAlpin 2001). These changes in the fire regime are thought to have fragmented Tjakura populations across the Western Deserts. The introduction of the cat and fox has also increased the pressure on isolated populations of Tjakura (McAlpin 2001).

In recent years, work done by ecologists and anecdotal evidence from Traditional Owners has indicated that many areas that once supported consistent Tjakura populations as recently as the 1950s and 1960s are now barren or have greatly reduced numbers of lizards (McAlpin 2001). These results prompted the Threatened Species Network to call for Tjakura to be listed as nationally vulnerable in the 1990s and form the Tjakura Recovery Team. The Tjakura Recovery Team determined the need for more data on current Tjakura distributions, especially in the Western Deserts, the impact of predators and fire history.

The Ngaanyatjarra Council Land Management Unit, based in the remote Aboriginal community of Warburton Ranges, Western Australia, has been involved in the Recovery Team since its inception. The Ngaanyatjarra Council Land Management Unit, Traditional Owners and community members from Warburton and nearby Patjarr community have worked with ecologists over the past four years to locate new populations of Tjakura. The extensive traditional ecological knowledge held by people from these communities and the fact that they still continue to hunt and travel has made possible the location of several new populations of Tjakura. As well, Traditional Owners' knowledge has been essential in the collection of ecological data.

The Ngaanyatjarra Council Land Management Unit has conducted six field trips between 2000 and 2004. The trips have involved over twenty community members in directional surveying of potential habitat, recording burrow activity, number of occupants, predator sign and fire age on a GIS database as well as conducting patch burning to improve habitat for Tjakura. So far over thirty burrows have been recorded at three sites around Patjarr and two sites around Warburton. Anecdotal evidence from community people has hinted at the possibility of other Tjakura populations around Warburton. These will be investigated in future surveys.

The surveys have shown that Tjakura occur in two land types, in *rirra* country around Patjarr and *pila* country around Warburton. The majority of burrows located so far have been recorded in *rirra* country. This is as a result of the interesting phenomena of 'vegetation islands'. In *rirra* country, almost exclusively, Tjakura burrows were found within 'vegetation islands'. These islands of shrubs, consisting of *Eremophila* spp, *Goodenia* spp, *Scaevola* spp, *Rulingia loxophylla* and *Leptosema chambersii* are clearly visible, several hundreds of metres apart, within a vast sea of spinifex. Surveying within this habitat becomes a process of driving cross-country systematically checking each island. The islands are hot spots of biodiversity, housing other reptile and mammal burrows within the largely barren spinifex-dominated surrounds. In comparison, the surveys conducted in *pila* country have revealed no such indicators for the location of Tjakura burrows and therefore the search effort was more intensive and the strike rate lower. It appears at this point that Tjakura are surviving in the Warburton, Patjarr area at least in areas close to communities and roads where there is regular patch burning.

The Threatened Species Network funded Tjakura surveys and surveys of other threatened species on the Ngaanyatjarra Lands provide an important opportunity for people from the Ngaanyatjarra Lands to practice, and be paid for, traditional land management work. This work also provides a more important opportunity for elders to pass on their unique and extensive cultural and ecological knowledge to younger generations.

REFERENCES

McAlpin, S. (2001). The Recovery Plan for the Great Desert Skink (*Egernia kintorei*) 2001-2011. Arid Lands Environment Centre, Alice Springs.

DEVELOPING RESEARCH PARTNERSHIPS BETWEEN CSIRO AND INDIGENOUS ORGANISATIONS

Jocelyn Davies

CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs, NT 0871

CSIRO is exploring how its research can be more responsive to indigenous people's concerns and issues. Action is underway through:

- My work at the Centre for Arid Zone Research. *Engaging Indigenous Partnerships*, a project co-funded by CSIRO and Desert Knowledge Cooperative Research Centre[1], aims to develop strategic research directions in partnership with indigenous organisations to meet priorities of indigenous people in desert Australia. It involves capacity building inside and outside CSIRO.
- CSIRO's participation in the Desert Knowledge CRC with two Alice Springs based Indigenous organisations – Central Land Council and the Desert Peoples Centre (a partnership of Batchelor Institute of Indigenous Tertiary Education and the Centre for Appropriate Technology).
- A CSIRO wide Organisational Learning project on the Cultural Context of Knowledge and Research that includes a review of international, national and CSIRO experience in conducting research with and for Indigenous people, an issues paper and workshops.

GOALS AND PRIORITIES

CSIRO's interest in research partnerships with Indigenous organisations is part of its overall concern with research approaches that benefit both the public good and private stakeholders. CSIRO Sustainable Ecosystems wants its research to help Australian ecosystems sustain viable enterprises, allowing biodiversity to prosper, and supporting the development of robust communities.

Indigenous people's priorities in desert Australia include jobs and independence, ending poverty and welfare dependency; respect and protection for cultural values and cultural property; recognition for people and for how culture and nature are interconnected; protecting and maintaining traditional knowledge; effective participation in decision making about management of traditional country and an equitable share in the flow of benefits from traditional country.

PARTNERSHIPS IN RESEARCH – SOME INDIGENOUS EXPERIENCES

In the A͟nangu Pitjantjatjara Lands, a 10 year biological survey program was a partnership between the SA Department of Environment and Heritage and A͟nangu (Yankunytjatjara and Pitjantjatjara people) (Robinson *et al.* 2003). A͟nangu, with support from their A͟nangu Pitjantjatjara Yankunytjatjara Land Management service, decided what traditional knowledge was collected. They control access to it. The survey set directions for ongoing biodiversity management involving traditional owners and scientists.

In north-east Arnhem land, turtle research was conducted in partnership between Dhimurru Land Management Aboriginal Corporation and Dr Rod Kennet (then of the Centre for Indigenous Natural and Cultural Resource Management, NT University) for several years in the 1990s (Kennet *et al.* 1997). The partnership strengthened Aboriginal and scientific understandings, and turtle conservation.

In South Australia, the Strategy for Aboriginal Managed Lands, documented in 1999, built on partnerships between the SA Government, Indigenous Land Corporation and Aboriginal landholding bodies to improve natural and cultural resource conditions on Aboriginal managed lands. It researched land management priorities and support needs. Partnerships have continued to evolve in the new Aboriginal Lands Integrated Natural Resource Management Region and now include new relationships with other regional resource management bodies in SA and interstate.

[1] DISCLAIMER: This paper does not necessarily represent the views of DK-CRC partners.

Government health and community service agencies have a new interest in collaboration and in partnerships with Aboriginal organisations (see Wakerman and Mitchell 2004). Their starting point is different to CSIRO's. Spurred by Indigenous leaders' and other critique that welfare policies hold back improvements in Indigenous well being, governments are seeking partnerships with Aboriginal communities that recognise mutual obligations for reducing disadvantage and welfare dependency.

WHAT MAKES A PARTNERSHIP EFFECTIVE?

A partnership should meet the needs of each partner in a better way than any partner working alone. Partnerships involve benefits and responsibilities for each partner, in an equitable balanced relationship. Research partnerships can produce better research outcomes such as through more appropriate framing of research questions and better adoption of results. Partnerships need time, flexibility and extensive negotiation to develop. Trust is critical in partnerships; many people say it is the key ingredient. But research is often not trusted by Indigenous people. Like Indigenous people's other experiences of colonisation, research has been invasive and exploitative, offensive to their dignity and cultural protocols, and blind to their values, knowledge and wisdom.

Developing trust involves engagement between people over time with openness and honesty - sharing objectives and needs, values and principles, based on mutual respect. Research involving indigenous knowledge and cultural resources carries an ethical responsibility to Indigenous communities and cultural groups as well as to the individuals who are directly engaged in the research. Indigenous people ask that research processes respond to six core values of their culture – reciprocity, respect, equality, responsibility, survival and protection, and spirit and integrity (NHMRC 2003). These and other ethical considerations are as fundamental in the design and conduct of research as scientific considerations (NHMRC 1999).

HOW DOES TRUST DEVELOP FOR RESEARCH PARTNERSHIPS?

- *Respect between individuals.* Trusting personal relationships, built up over time, are the foundation for many research partnerships.
- *Participatory research methods.* Drawing on the expertise of Indigenous community members and building in their participation throughout the research process – in design, data collection, analysis and evaluation of the research – transforms power relations. This is very different to involvement of indigenous people only as paid informants, or research assistants (e.g.: see the Arctic Borderlands Ecological Research Cooperative - http://www.taiga.net/coop/).
- *Agreements, MOUs and project management procedures.* Negotiation of agreements can allow trusted relationships to extend over time between organisations, reducing reliance on relationships between individuals (e.g. the Cultural Safety Contract between Rakiura Maori and University of Otago - http://www.otago.ac.nz/titi/bicultural.html).
- *Indigenous peoples' control over the research process.* Indigenous people and organizations are increasingly setting priorities, leading and implementing research activity, promoting their trust in the process (e.g. experience of the CRC for Aboriginal and Tropical Health).

REFERENCES

Kennet, R., *et al.* (1997). The Dhimurru miyapunu project. *In* Kennet, R.; *et al.* (eds). *Marine Turtle Conservation & Management in Northern Australia*, NTU, Darwin: 69-75.

NHMRC, (1999). *National statement on ethical conduct in research involving humans.* Commonwealth of Australia, Canberra.

NHMRC, (2003). *Values and ethics: Guidelines for ethical conduct in Aboriginal and Torres Strait Islander Health Research.* Commonwealth of Australia, Canberra.

Robinson, A. C. *et al.* (2003). *A biological survey of the Anangu Pitjantjatjara lands, South Australia. 1991-2001.* Biodiversity Survey and Monitoring Section, DEH, Adelaide.

Wakerman, John and Mitchell, Julia (2004). Intersectoral collaboration: what are the factors that contribute to success? Centre for Remote Health, Alice Springs. DK-CRC Research Report.

LEARNING THROUGH LAND: SKILLING ALL GENERATIONS TO CARE FOR COUNTRY

A. Drenen [1], R. Edwards [1], M. Hourihan [1] and D. Ward [2]

[1] Ngaanyatjarra Council Land Management Unit, PMB 71, Warburton via Alice Springs NT 0872
[2] Ngaanyatjarra Education Area, WA DET, PMB 5, Warakurna via Alice Springs NT 0872

Land management offers real opportunities for Indigenous employment in the rangelands. The provision of education and training programs to meet land management objectives is a challenge for both indigenous and non-indigenous land management and education systems. Senior Traditional Owners hold an extensive ecological knowledge system and are charged with the responsibility for its practice and delivery. If education is to be relevant to Indigenous people and achieve contemporary land management objectives, it must build on this existing knowledge base.

For the Ngaanyatjarra people in the Western Desert region of Western Australia, a model of land management and caring for country education is gradually coalescing. There is no particular lead agency or institution, and no particular model being sought. Equally, there is no articulated vision directing or influencing its development. Instead, components are being developed in an opportunistic and unstructured fashion that is presenting its own opportunities for a continuum of education spanning the generations and incorporating mainstream education and the practice and transmission of traditional ecological knowledge.

Resources on the Ngaanyatjarra Lands are not inconsiderable and encompass eleven communities with over 2000 Ngaanyatjarra members across 18,586 sq km. Each community has a WA Department of Education and Training Remote Area School providing education services to students from ages five to about fifteen.. In Warburton there is also the Ngaanyatjarra College, an independent, community-controlled, registered training organization that provides a range of post-secondary vocational training programs. In addition, the Ngaanyatjarra Council has an established Land Management Unit that services the Indigenous Protected Area and greater Ngaanyatjarra estate.

Ngaanyatjarra people have an unbroken history of occupation and land management practice on their Lands that are unique in that industries such as mining or pastoralism have never taken hold. Consequently the body of traditional ecological knowledge that sustains the landscapes and maintains the unique biodiversity values is relatively intact. Today, every opportunity must be taken to get people back onto country to practice this knowledge and to facilitate its appropriate transmission to younger generations. The Land Management Unit is continually seeking creative ways to promote inter-generational transmission of traditional ecological knowledge and aims to provide a broad range of opportunities for this to occur.

Mainstream education and attendance at school is a very small part of the overall life of Ngaanyatjarra people. Consequently the time spent at school must provide relevant education – but relevant to participation in both the local indigenous and non-indigenous community. With support from the WA Department of Education and Training, the Ngaanyatjarra Council embarked on the development of its own curriculum using land-based activities and bush trips to bridge the gap between traditional and institutional knowledge transmission processes and bring relevance to mainstream school-based education while simultaneously passing on the knowledge needed for caring for country.

In 2003, the Land Management Unit implemented the *Learning Through Land* project that arose from the curriculum. It is based on contextual learning in overnight bush camps where the land-based activities and learning experiences raise awareness of the issues and work required to maintain and enhance the environment and heritage values of the Ngaanyatjarra Lands. The knowledge transmission and reception is undertaken with practice, guidance and direction from senior practitioners at appropriate times and places. These activities affirm cultural responsibilities and contribute directly to the maintenance of traditional ecological knowledge and the sustainability of land management practices. An additional strength of this project, that cannot be underestimated, lies in the relationships fostered between schools, community members and the Land Management Unit as a result of the time together.

The Land Management Unit is also involved in a wide range of activities from which schools can draw inspiration for classroom work, including: feral animal management; rock hole cleaning; cultural site maintenance; surveying and monitoring for rare and threatened species; collection of resource-use data; and fire monitoring. Such activities provide significant opportunities for literacy and numeracy development in the classroom.

Land management is inextricably linked with all activities of Ngaanyatjarra day-to-day life. Health and well-being in its total definition demands that land management be practiced. The Ngaanyatjarra Health Services delivers some of its training packages through methodologies similar to that used for the *Learning Through Land* program with significant spins-offs to land management including: monitoring of land condition; burning for hunting; harvesting of resources; teaching of children; reaffirming the position of the senior practitioners; and, getting young mothers and senior women onto country. The Land Management Unit and the Health Services are jointly investigating ways of sharing resources to ensure that this methodology can be expanded.

Some schools have students participating in Vocational Education Training and have expressed interest in a land management stream. The Ngaanyatjarra College is currently recruiting trainees in the nationally accredited Certificate of Conservation and Land Management. Trainees will develop the skills and language to enable participation in the dialogue with external land management agencies. Delivery of the training will rely heavily on the participation and employment of people skilled in traditional ecological knowledge as mentors and trainers.

The emerging model for land management education and caring for country is moving towards a life-long learning process incorporating both traditional ecological knowledge and contemporary land management issues with delivery provided through both traditional means and recognized institutional structures.

FERAL HERBIVORE CONTROL ON THE A̲NANGU PITJANTJATJARA LANDS, 2004

A. Knight and R. Hall

APYLM, PMB 227, Umuwa, via Alice Springs, NT 0872

THE A̲NANGU PITJANTJATJARA YANKUNYTJATJARA LANDS (APY LANDS)

The A̲nangu Pitjantjatjara Lands cover 10.7 million hectares, approximately 1/8th of the state of South Australia, in its remote and arid northwestern corner. A population of 2000 – 3000 *a̲nangu* (people of the Pitjantjatjara lands) are scattered across 33 communities and outstations. English is a second language to Pitjantjatjara, Yankunytjatjara and Ngatatjara, and many cultural practices are vastly different to those of *pir̲anpa* (white people). Nearly 2 million hectares are managed as Indigenous Protected Areas. Surface water is sparse and most watering points are only rain fed rock holes that were traditionally maintained by the indigenous custodians of these sites. There are very few permanent waterholes. A̲nangu Pitjantjatjara Incorporated under the Pitjantjatjara Land Rights Act administers the lands. An APY member nominated executive advises a salaried Coordinator of the Anangu Pitjantjatjara Yankunytjatjara Land Management branch, Lexie Knight, and its 'Feral Control' portfolio is managed by the 'Feral Control Facilitator', R. Hall.

THE FERAL HERBIVORE PROBLEM

An aerial survey in August 2000 estimated that 4000 – 7000 horses, 1000 – 4000 donkeys and 2000 – 4000 camels roam the APY Lands. However a run of good seasons combined with relatively low predation, harvest and control have resulted in large population increases by both migration and breeding. The combined opinion of traditional owners, TO's, and involved professionals agree on a current estimation of about 20,000 camels on the APY lands. This could double in the next five years if seasons continue to be good and if dedicated and well-directed and well-resourced control methods are not adopted early and advanced speedily. Horse and donkey numbers still seem close to the estimates of the August 2000 aerial survey. It is clear that the present populations of large feral herbivores are so high, that even in short periods of drought all waterholes are severely degraded. Worse still, unlike *malu* (kangaroo) and *kalaya* (emu) that are important resources of *kuka* (meat), a̲nangu do not eat donkey and horse. While some a̲nangu eat camel, the beasts weigh up to 1500 kg and even calves are generally too large for anangu to use effectively.

APY APPLICATION TO THE REMOVAL OF FERAL HERBIVORES

In general *a̲nangu* are against killing of ferals simply as an environmental measure. There have been recent discussions about a mobile abattoir for processing camels and donkeys in-situ on the 'Lands however present opinion is generally still against such practices. Discussions continue and an emerging industry interest is gearing for competitive bidding for feral carcass 'product'. Such interest will possibly gain support in time as proposals develop, product viability improves, and local awareness of alternatives is explored.

Methods of live feral capture and export are presently being developed simultaneously among several community-based teams in the APY Lands. Yards of portable panels are erected close to good sources and animals are either trapped or mustered. Musters are conducted in a contemporary manner using motorbikes, 4WD's and occasional air assistance. Air support can be useful and economical for large immediate orders when contractual transport is available. However for slower markets where longer-term agistment is necessary for depoting stock, then local resources cannot handle so many animals quickly enough and the smaller and less expensive mustering methods are sufficient to keep a one-trailer truck busy. With a turnaround of over 1,000 km between the western-most source and the eastern-based agistment paddocks, it can easily take a week to load, transport, unload, service equipment and rest operators between loads. One standard 40 foot stock trailer can carry just eighteen large camels, or up to 60 donkeys. Large camels are difficult to load and require some training to prepare them for a safe, stress-free and timely removal from the yards. All stock require feeding and watering while in the yards and the better they are managed during these times, the better the returns. Proper planning and preparation is essential for the economic success of supplying distant markets with marketable feral product.

Many challenges affect local ability to control these large ferals. Skill pools are still developmental and resources yet primitive and basic at best. Teams have applied themselves well to the tasks of evolving methods suited to local conditions and pooled skills, experiences and resources are improving. Intercommunity exchanges have centralized depoting facilities and developed some shared equipment. Effective strategies have been prioritized and good contributions made to the few orders that have actually been exported by the Central Australian Camel Industry Association, CACIA, this year.

A program of infrastructure and skill development is well progressed to address control issues and seems parallel to a rising curve of market demand.

MARKET FACTORS

APYLM is a corporate member of the CACIA that has gained an international reputation for professionalism and reliability for the supply and export of camels from Australia. By the end of 2002 orders had risen from 12 camels per fortnight for domestic consumption, to 300 per month mostly for 'halal hamburgers' in Malaysia. The Iraqi war and its attendant political and economical ramifications, and the activities of both importers/exporters and animal activists effectively ceased the export orders of 'feral product' from Australia throughout most of last year. Orders began to increase again towards the end of 2003, however shipping difficulties have continued to frustrate efforts to fill them. The industry is presently too small to utilize whole ships and decks are made available by arrangement with the principal shipping contractors, the sheep and cattle businesses. Many factors determine such third party agreements. Recent lowering of the Australian dollar again for example has improved the ability of the overseas market to buy Australian beef and now the swollen backlog of live cattle means less room for camels.

Product demand however is rising and two of the largest orders to date are presently in negotiation and these could see an additional 10,000 camels removed from Australia in the next year. An ability to begin supplying these orders rests partly with three middle-eastern countries that are yet to agree to 'multi-port-discharge' of stock from Australia, an arrangement apparently attractive to all parties. Camels are fetching similar to slightly lower prices at the wharves to cattle, ranging between $1:25 to $2:00/kg live-weight at the wharf. Trucking costs are averaging just over $100/head from the 'Lands to the wharf, (to either Darwin or Adelaide), and camels typically weigh from 350 kg to over a ton. Larger animals are presently slaughtered for the domestic market due to height restrictions on the ships; camels must be 0.1 m below the lowest point of their shipping accommodation – usually the loading door! Recently, domestic slaughter of camels within Australia has gained impetus with several abattoirs now accepting camels, but at lower prices than the export market.

Horsemeat supply is a marginal enterprise and a risky, dangerous undertaking. Contractor interest in the more difficult hilly terrain seems likely to enable an effective control in those areas in the near short-term. Development of other resources will assist in longer-term control in less difficult terrain.

Donkey control seems best tackled by a mobile abattoir licensed for 'wild-kill' but such arrangements are embryonic and a forecast of likely results would be premature. If such arrangements were to remain untenable, then removal and control will be expensive and problematic. Even if an acceptance of such procedures were to allow its practice, returns are presently poor, but contributive nonetheless to a workable control strategy.

Biodiversity Management
(Poster Group Five)

SHIFTING MANAGEMENT'S PERCEPTIONS OF BIODIVERSITY CONSERVATION THROUGH A PARTICIPATORY PROCESS IN THE SOUTHERN RANGELANDS OF WA

A.E. Bushell

Curtin University, Centre for the Management of Arid Environments,
PO Box 22, Kalgoorlie WA 6433

Off-reserve conservation in the southern rangelands of Western Australia (WA) is gaining momentum at the enterprise level through the participatory Ecosystem Management Understanding (EMU) process. The project evolved from the Gascoyne-Murchison Strategy (GMS) during 2000 and four years later, three additional staff joined the initial team totalling six full time equivalent members with the potential for growth in the future. Its framework has been used to develop management capacity from the Carnarvon Basin north of Carnarvon extending through to the Nullabor Plain in WA. Its approach engages managers of land (Murchison Land Conservation District Committee and the Ecosystem Management Unit 2002) and is a vehicle for regional progress (Pringle *et al.* 2003). Pastoralists are the main participants however work is also being undertaken with indigenous communities, mining companies and the Department of Conservation and Land Management. This diverse involvement may potentially lead to improved catchment management.

Principally, the EMU process builds local capacity. Its construction is a gradual process from a two-day baseline mapping exercise to capture land managers knowledge and introduce or reacquaint them with principles of landscape ecology and sustainable pastoralism. Given time (three to four months) this fundamental understanding of landscape patterns and processes germinates and managers begin to see their land systems from a perspective other than stock management, mostly for the first time. At this stage the EMU team spends an intensive two to three day reconnaissance with land managers who are open to adopting either new management decisions or altering existing ones. This moves managers towards practices developed from an ecological perspective. Developing land managers' capacity to "play" with their management techniques and observe how these fit within the landscape either maintains or alters their management accordingly. Hence, it is a management cycle of continual performance rolling towards the ultimate goal of sustainable pastoralism based on sound ecological principles.

From this process and with ongoing collaboration with the EMU Team, a significant number of land managers have committed to, or are engaged in, active on-ground preservation and restoration activities. This includes, but is not limited to, land managers that have:

- Internationally certified environmental management systems in place.
- Developed specific management activities for conservation of biodiversity (and protection of rare flora) as well as publishing their perspectives on biodiversity in relation to responsible management.
- Significantly changed their grazing management practices including de-stocking, re-location of waters and fencing programs to protect fragile areas, particularly floodplains and; protected areas of aboriginal and cultural significance.

Land managers wearing their new ecological glasses feed back into the EMU process in a number of important and significant ways. Once land managers are formally engaged, their experience is passed on to industry, initiating interest from land managers who have yet to take on an ecological management perspective. It produces a flow-on effect like the way ripples radiate when a pebble has been dropped into a pond. Additionally, as ripples spread their diameter increases, as does the scale at which the EMU process can be applied. Larger scale, incorporated projects have evolved from the capacity built at the enterprise level. This has led to the development of catchment-scale restoration projects involving officers from different government departments, mostly from district departments. These industry-led, catchment scale, multi-disciplinary and multi-departmental projects potentially open doors, as it has for numerous land managers, for cohesion between institutions, enabling community-driven ecological sustainability in WA's rangelands.

REFERENCES

Murchison LCDC and the Ecosystem Management Unit (2002). The Murchison River Project: Pastoralists restoring health to the Murchison River catchment. Shifting Camp: Proceedings of the 12th Biennial Australian Rangeland Society Conference, pp. 312-313.

Pringle, H.J.R., Tinley, K.L., Brandis, T., Hopkins, A.J.M., Lewis, M., and Taylor L. (2003). The Gascoyne-Murchison Strategy: A people-centred approach to conservation in arid Australia. International Rangelands Congress 2003, Durban, South Africa.

MODELLING THE IMPACTS OF HABITAT DEGRADATION OR LOSS ON VERTEBRATE POPULATIONS IN WESTERN NEW SOUTH WALES

Murray Ellis and Michael Bedward

Department of Environment and Conservation, PO Box 1967, Hurstville NSW 2220

ABSTRACT

CafeAnimal is a spatially explicit, rule-based simulation program for modelling the population dynamics of territorial vertebrates. Model features include territories with floating boundaries; the use of map sequences to consider temporal and spatial changes in habitat resources; animal movement modelled in continuous space; the ability to depict various forms of social organisation; and tracking of individuals, groups and territories over time. CafeAnimal is used to model the responses of selected species to past sequences of clearing and possible future landscape scenarios; to model responses of species to varied fire regimes; to identify species at risk of continued negative responses to past land management; and to explore landscape design questions. The models are being explored to determine patterns in population structures and distributions that can be used to access the condition of real populations from snapshot or short-term field studies.

INTRODUCTION

The eastern margins of the NSW rangelands have seen a shift from simple grazing systems to multiple agricultural activities. Clearing of native woodlands in this region commenced over 150 years ago but has increased markedly since the 1950s, and fire regimes have varied greatly across time, with a corresponding change in native flora and fauna. In such altered landscapes, fauna species may take years to reach new population equilibrium levels even after clearing has ceased or new fire management programmes are implemented. CafeAnimal was developed for research into predicting biodiversity outcomes for alternative policy and management options in the agricultural landscape of western New South Wales.

METHODS

Life history parameters, such as fecundity and mortality, are set as probabilities per timestep, territory size is limited by a maximum radius and social structure is described as maximum and minimum allowable group compositions. Resources that vary in time and/or space are mapped as a series of raster datasets, and rules about the minimum requirements for each resource are set. This allows territory sizes to change with varying resource availability. The model currently uses annual time steps and at each step determines whether each individual survives, whether each group has a suitable composition and resources to remain cohesive and reproduce successfully, and the path and fate of any dispersing individuals.

Two species with published life history data were selected to trial the software. The Brown Treecreeper (*Climacteris picumnus*) was used to test the ability of the model to represent species that live in large and structured social groups, and the Malleefowl (*Leipoa ocellata*) used to test the capabilities with changing habitat quality due to fires. Resource mapping for the treecreeper simulations was sourced from a series of vegetation maps of the Nyngan region from the last 30 years reclassified to presence/absence of woodland, with the distribution of woodlands for the last year used for a further 66 years to represent the effect of cessation of clearing. Resource mapping for malleefowl was sourced from fire management simulations representing four management scenarios for mallee lands being conducted by Bradstock *et al.* (in press), giving time since last fire which was converted to a malleefowl carrying capacity based on Benshemesh (1992). The fire simulations were conducted assuming predominantly westerly winds during wildfires. Both sets of maps were at 1ha resolution and at annual increments. Each simulation was replicated 50 times covering 100 years.

RESULTS

At the higher published survival rates for treecreepers in the New England Tablelands (Cooper 2000, Higgins *et al.* 2001), the simulations were able to produce stable populations that showed a diversity of group compositions (one to seven birds per group), with the modal size varying between three and four birds, and less than 15% of groups were composed only of males. The majority of the population was restricted to the larger patches in the landscape but adjacent areas were colonised at times. At the mid to lower range of the published survival rates from the Central West of NSW (Higgins 2001) group sizes declined with time, with the proportion of all male groups increasing. Groups in isolated and marginal remnants in all simulations tended to become composed only of males, followed eventually by local extinctions. At the lowest survival rates landscape wide extinction resulted. Dispersing females were usually absorbed by neighbouring territories.

Malleefowl modelling showed that burn scenarios producing coarse age mosaics were capable of supporting malleefowl populations. For example, prescribed burns of 1% of the landscape p.a. with a 0.1 probability of wildfire ignition p.a. produced vegetation patterns supporting 13 to 121 active territories (mean 69). Unlike the modelling of Bradstock *et al.* (in press) which used the density of stands of old *Callitris verrucosa* to indicate suitable malleefowl habitat, this modelling using mallee age to determine suitability predicted that a scenario of prescribed burning of 5% of the landscape p.a. with a 0.2 probability of wildfire ignition p.a. resulted in extinction, usually within 70 years (maximum 86 years), with less than 12 territories being occupied for most of the simulations. The distribution of active territories fluctuated across all simulations but more commonly occupied the western parts of the landscape.

DISCUSSION

The software reproduced the male biases reported by Cooper (2000) for declining treecreeper populations. This was both in terms of population structure and the geographic arrangement. The limited dispersal of females can be explained by the ability of groups of territories to absorb produced females, rather than the inability of females to make long movements as hypothesised by Cooper (2000). Some predictions about malleefowl differed from previous work. While the distribution of mature *Callitris verrucosa* and mallee stand age are correlated (Bradstock *et al.* in press), which is the better predictor of malleefowl habitat would need to be assessed.

The variation in results between two modelling methods for malleefowl show that care is needed if modelling is to be applied to land management, and that field data need to be compared with model predictions after management is implemented to ensure its aims are being achieved. Models that report on a wide variety of a species' attributes allow for more possible ways of comparing field and modelled data, and for the use of snapshot samples of population structure rather trend data.

REFERENCES

Benshemesh, J. (1992). The conservation ecology of Malleefowl, with particular regard to fire. Ph.D. Thesis. Monash University, Clayton.

Bradstock, R.A., Bedward, M., Gill, A.M., and Cohn, J.S. (in press). Which mosaic? A landscape ecological approach for evaluating interactions between fire regimes, habitat and animals. *Wildl. Res.*

Cooper, C.B. (2000). The Behavioural Ecology and Conservation of an Australian Passerine, the Brown Treecreeper (*Climacteris picumnus*). Ph.D. Thesis. Virginia Polytechnic Institute and State University, Blacksburg.

Higgins, P.J., Peter, J.M. and Steele, W.K. (Eds) (2001). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 5. Tyrant-Flycatchers to Chats.* Melbourne: Oxford University Press.

BIODIVERSITY AT THE "TOORAK" GRAZING TRIAL, NORTHWESTERN QLD

A. Fisher [1], A. Kutt [2], J. Risler [1], D. Milne [1], J. Petit [3], A. Andersen [4] and D. Phelps [5]

Tropical Savannas Management Cooperative Research Centre, and
[1] DIPE, PO Box 496, Palmerston, NT 0810, [2] EPA, PO Box 5391, Townsville Qld 4810,
[3] Institut Supérieur d'Agriculture Rhône Alpes, 31 Place Bellecour, 69002 Lyon, France,
[4] CSIRO Sustain. Ecosyst., PMB 44, Winnellie NT 0821, [5] QDPI, PO Box 519, Longreach Qld 4730

INTRODUCTION

There is increasing impetus for the maintenance of biodiversity values throughout Australia's rangelands. This necessitates an improved understanding of the effects of grazing management on biodiversity, invoking the question of whether there is a threshold of grazing intensity above which ecological sustainability is compromised. A substantial impediment to addressing this question is the shortage, in many rangeland regions, of comparable areas having a broad range of precisely-known grazing levels consistently applied over long periods. In this paper we describe a preliminary biodiversity assessment within a long-term grazing trial in the Mitchell grasslands of northwestern Queensland, a region where much of the biota is still poorly known.

METHODS

The study was at Toorak Research Station (21.0°S 141.8°E), where an unreplicated grazing study was established in 1984. The paddocks (ranging in size from 7 to 57 ha) have since been grazed by sheep at five levels of pasture utilisation (10, 20, 30, 50 and 80%) and there is also a 1 ha exclosure (Fig. 1). Stock is watered from a bore drain and there is patchy grazing even within these small paddocks (Phelps and Orr 2002). Vegetation is grassland dominated by *Astrebla* spp., on cracking-clay soils.

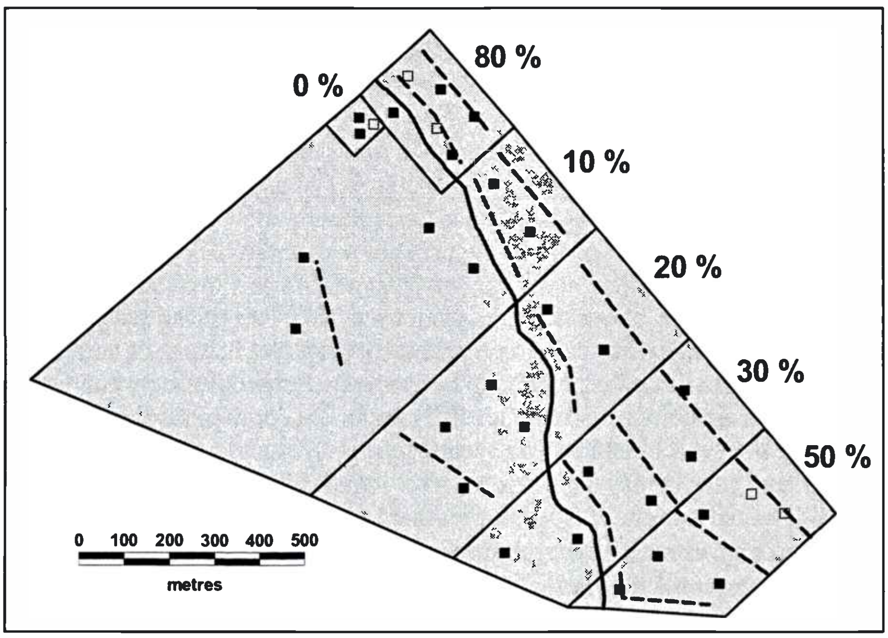


Figure 1. Layout of the Toorak grazing trial, showing the boredrain (solid line), sample sites (solid squares, all taxa; open squares, plants and habitat data only) and bird transects (dashed lines).

Biodiversity sampling was carried out in May 2003. Mammals, reptiles, ants, plants, vegetation structure, stock use and other habitat attributes were sampled at two to six 20x20 m sites within each paddock, with sites chosen to incorporate variation in utilisation within each treatment (Fig 1.). Birds were counted along two or three 250m x 50m transects within each paddock (plus instantaneous counts within the exclosure), each transect being walked a total of 11 times over three days.

RESULTS

A total of 93 plant, 21 ant, 16 bird, 8 reptile and 3 small mammal species were recorded within the grazing trial. A poor wet season prior to sampling probably contributed to low richness and abundance of most animal taxa, as well as low plant cover. A brief summary of some results is given in Table 1. There was considerable within-treatment variation in many habitat attributes and most did not differ significantly between treatments. Plant and litter cover generally decreased with utilisation, while perennial grass basal area was greatest at intermediate grazing levels (notably, most perennial grasses had died in the 0% exclosure). Plant and ant richness differed between treatments, but there was not a simple linear relationship with utilisation. Bird and reptile richness were independent of utilisation, while the higher mammal richness at high utilisation levels was due to the presence of the dasyurid *Planigale ingrami.* Plant composition differed significantly with utilisation level, as did (but less clearly) ant composition. Many plant species showed decreaser or increaser responses to utilisation level, with a few species most or least frequent at intermediate grazing levels. Similar response patterns were also evident for smaller numbers of ant, mammal, reptile and bird species.

Table 1. Summary data for utilisation treatments. Treatment means were compared with Kruskal-Wallis tests (H). Composition was compared using ANOSIM (R); the table shows which other treatments are not significantly dissimilar. (ns, P>0.1; *, P<0.1, **, P<0.01; ***, P<0.001).

	0%	10%	20%	30%	50%	80%	H
Understorey cover %	19.7	13.6	18.8	14.8	12.7	7.6	3.9 ns
Litter cover %	23.9	9.3	8.6	4.0	3.1	1.8	25.6 ***
Perennial grass BA %	1.2	5.7	7.5	7.3	5.5	5.3	8.9 ns
Richness: Plant	27.3	29.7	19.0	24.8	24.8	29.5	15.0 **
Ant	6.5	2.5	6.0	3.5	4.8	3.3	14.9 **
Bird	1.0	3.3	2.7	2.7	1.7	6.0	6.1 ns
Reptile	1.0	0.8	0.8	0.5	0.0	1.5	8.1 ns
Mammal	0.0	0.3	0.0	0.3	0.8	0.8	9.5 *
Composition: Plant	none	none	none	50	30	none	0.52 ***
Ant	all	none	30	0,20,30,50,80	0,30,80	0,30,50	0.16 *
Bird	all	all	all	all	all	all	0.09 ns
Reptile & mammal	all	all	0,10,80	0,10,50,80	0,10,30,80	all	0.29 **

DISCUSSION

This study supports the findings of recent investigations in a variety of rangeland ecosystems, that the effects of grazing on biodiversity are expressed primarily through changes in composition, rather than in species richness, and that the nature of the effect varies substantially between taxa. This suggests that maintenance of heterogeneity of grazing levels is important for maintaining biodiversity values. A challenge for ecological research, and for land managers, is to elucidate the 'optimal configuration' of such heterogeneity, and how it may be achieved in a logistically and economically feasible manner. The preliminary biodiversity study at Toorak presented tantalising (rather than clear-cut) results and further intensive sampling, in more favourable seasonal conditions, is desirable. Future analyses will also consider the importance of small-scale (within-paddock) variation in grazing intensity.

ACKNOWLEDGEMENTS
We are grateful to David Orr and QDPI staff for the information and support they provided. Birgit Hallenstein helped with fieldwork, Tony Hertog and Ben Hoffmann with ants and the Northern Territory and Queensland Herbaria with plants. The study was funded by the Tropical Savannas CRC.

REFERENCES
Phelps, D.G. and Orr, D.M. (2002). Managing Mitchell grass - grazing patterns in small paddocks. Proceedings of the 12th Australian Rangeland Society Conference, Kalgoorlie, Sept 2002, pp. 331-3.

BILBIES AND BETTONGS AS ECOSYSTEM ENGINEERS: PRELIMINARY RESULTS FROM ARID SOUTH AUSTRALIA

Alex I. James [1], *David J. Eldridge* [1] *and Brydie Hill* [2]

[1] School of Biological, Earth and Environmental Sciences, University of NSW, NSW 2052
[2] Arid Recovery, P.O. Box 150, Roxby Downs, SA 5725

BACKGROUND

Australia has experienced the highest recorded rate of recent mammal extinctions and range declines, and losses from the arid zone have been significant (Morton 1990). The Burrowing Bettong (*Bettongia lesueur*) and the Greater Bilby (*Macrotis lagotis*) are two species that were once widespread across arid Australia, and their foraging pits may have acted as resource traps that could be essential for maintaining landscape heterogeneity, nutrient cycling and vegetation productivity (Whitford and Kay 1999). Comparing the impact of these pits to those created by the Sand Goanna (*Varanus gouldii*) and the European rabbit (*Oryctolagus cuniculus*), an introduced herbivore, may explain if the ecosystem engineering role of these locally extinct species is still being maintained.

METHODOLOGY

The study was undertaken within a 60 sq km feral animal-proof exclosure near Roxby Downs in north-central South Australia. The landscape is characterised by parallel sand dunes and ridges, with intervening gibber flats. We selected three paddocks to examine the impact of animals on soil processes: 1) Main Exclosure, containing only native animals (e.g. bettongs, bilbies, goannas etc.), 2) First Expansion, where native mammals have not been introduced, and 3) adjacent mine sites containing rabbits but no bettongs or bilbies. Within each of the three paddocks three habitat units were sampled (dune, gibber, dune-gibber ecotone) and replicated three times, resulting in 3 paddocks x 3 habitat units x 3 replicates (n=27 locations). The density of diggings was assessed at each location along 50 – 150 x 2 m transects (depending on density). Animal digs were characterised according to shape and type of animal responsible, and measurements made of width, depth and length of each dig.

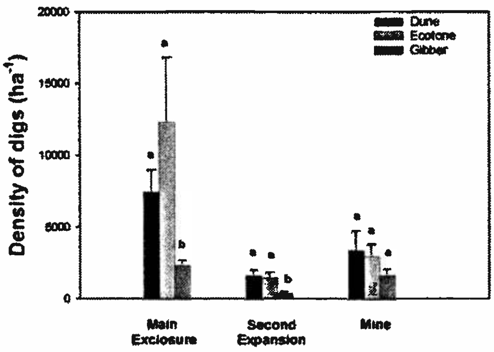
Within the Main Exclosure we collected soil from three microsites associated with each of 10 digs (within the pit below litter, adjacent to the pit, at the surface) resulting in 270 soil samples. Total carbon, nitrogen and sulphur were determined using a high combustion LECO CNS-2000 CNS Analyser. Finally, the relationship between dig size and the mass of excavated soil was determined by measuring 94 holes of differing size excavated by different animals (goannas, rabbits, bilbies and bettongs), calculating the volume of soil excavated, and correcting this using bulk density readings. Water infiltration was measured on disturbed and undisturbed soils in each habitat. General linear models with multiple error terms were used to examine differences in soil nutrients and dig densities across paddocks, habitats and microsites.

RESULTS

There were substantially more digs in the ecotones, followed by the dunes, and least numbers in the gibbers (Figure 1). The high degree of variability between replicate locations meant that only gibbers were significantly different from the other habitats. In general, most of the digging in the Main Exclosure were attributed to bilbies and bettongs (1600 – 19,400 digs/ha) compared with goannas (50 – 1,000 digs/ha). The simple product of hole width by length by depth, irrespective of the type of dig or animal creating it, explained 91% of the variance in mass of soil excavated ($F_{1,92}$=935, P<0.0001, Figure 2). Pits had major impacts on soil nutrients. Across all habitats, pits contained significantly more total carbon and total nitrogen compared with adjacent or surface soils ($F_{2,4}$=27.8 – 37.4, P<0.003). Pooled across microsites, gibber soils had significantly more carbon, nitrogen and sulphur compared with dune or ecotone sites ($F_{2,174}$=22.4 – 78.2, P<0.001). Disturbing the soil by digging increased the rate at which water moved into the soil.

DISCUSSION

Our preliminary results clearly reveal marked differences in soils created by the activity of semi-fossorial native animals. Bilbies and bettongs create a large patchwork of diggings while foraging for insects, plant roots and subterranean fungi. Our results indicate that the coarser-textured soils on the dunes and ecotones are preferred digging sites, though the data were highly variable. This level of activity may not reflect pre-European levels, as animal numbers in the Main Exclosure were artificially high, and under natural conditions animals would probably disperse to other areas.



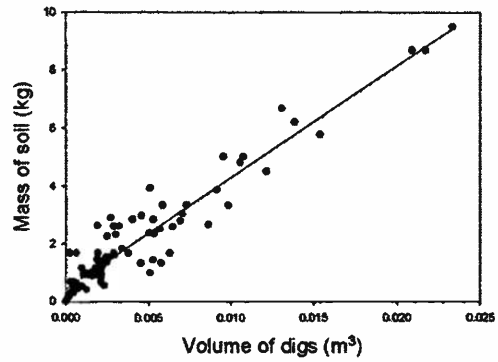


Figure 1. Density of digs (per ha) in relation to habitat and paddock. Different letters indicate a significant difference in density at P=0.05.

Figure 2. Mass of soil removed (kg) in relation to the volume of digs (per cubic m)

The second major impact of our study was that digs are acting as efficient resource traps ('fertile patches'), trapping litter and wind-blown sediment where it is broken down, enhancing soil carbon and nitrogen. Bilby and bettong digs are known to trap litter, particularly plant seeds, and the digs are likely to become safe sites for germination of vascular plants (Guttermann *et al.* 1990, Sparkes 2001). When the soil is disturbed by digging, the thin surface crust is destroyed, allowing water to run into the pits. On the gibber soils where soil clay contents are substantially higher (35-40% compared with 5-10% on the dunes), water is likely to pond, resulting in substantial benefits to seeds germinating in the pits. Our infiltration measurements confirm that water ponds on disturbed gibber soils for longer periods of time. Water infiltrating into the dunes may not be sufficient to initiate germination, but may stimulate the activity of litter-borne fungi associated with the pits. Further work will examine soil seed banks in the pits and the impact of these ecosystem engineers on soil surface health.

REFERENCES

Gutterman, Y., Golan, T. and Garsani, M. (1990). Porcupine diggings as a unique ecological system in a desert environment. *Oecologia* 85: 122-127.

Morton, S.R. (1990). The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model. *Proceedings of the Ecological Society of Australia* 16: 201-213.

Sparkes, S. (2001). A comparative study on the impacts of greater bilby *Macrotis lagotis* (Peramelidae) and the European rabbit *Oryctolagus cuniculus* (Leporidae) digs on vegetation structure in arid South Australia. BSc (Hons) thesis, University of Adelaide.

Whitford, W.G. and Kay, F.R. (1999). Biopedturbation by mammals in deserts: a review. *Journal of Arid Environments* 41: 203-230.

EFFECTS OF AN INTRODUCED PASTURE SPECIES ON BIODIVERSITY IN A TROPICAL SAVANNA WOODLAND

Alex S. Kutt [1] *and Alaric Fisher* [2]

Tropical Savannas Management CRC and
[1] Environmental Protection Agency, PO Box 5391, Townsville, Qld 4810
[2] Department of Infrastructure, Planning and Environment, PO Box 496, Palmerston, NT 0810

INTRODUCTION

In Queensland, Grazing Land Management packages are becoming widely adopted as a tool for assessing land condition, and the relative "health" of country. Within these packages, land condition indices are based on the extent of perennial grasses, bare ground and woody thickening. However, there is uncertainty whether these factors are also adequate surrogates for biodiversity status. In many cases there is considerable commonality between perceptions of healthy landscapes from both pastoral and biodiversity perspectives (relating to, for example, maintenance of a high cover and diversity of perennial grasses). Conversely these perspectives may substantially diverge. One example is the impacts of introduced pastures on landscape health. Areas with a high cover of palatable, perennial, introduced pasture grass are likely to be considered in good condition by the pastoral sector; but in poor condition from a biodiversity perspective. In this paper we present data from a study in northern Queensland savanna that illustrates this divergence.

METHODS

A flora and fauna survey was conducted in the Dalrymple Shire (20°S, 146°E, Einasleigh Uplands bioregion) between November 2002 and March 2003. A total of 48 one-hectare sites were located on five properties dominated by open *Eucalyptus* woodland on ferrosols (basalts), with the sites sampling a range of condition classes. The native groundcover was dominated by *Heteropogon* spp., *Bothriochloa* spp. and *Dichanthium* spp., but approximately half of the sites contained varying cover of the introduced pasture Indian Bluegrass *Bothriochloa pertusa*, a species considered palatable, perennial and productive. Mammals, reptiles, birds, ants, vascular plants, vegetation structure and other habitat attributes were sampled within each site.

RESULTS

A total of 138 vertebrate species (86 birds, 29 reptiles, 10 amphibians and 13 mammals), 152 species of vascular ground cover plants and 106 species of ant were recorded from the study sites. The relative cover of *B. pertusa* at these sites had a pronounced influence on composition of vertebrates, in particular birds (Fig. 1). Species such as Rufous Songlark, Weebill, Red-backed Fairy-wren, Western Gerygone and Golden-headed Cisticola were less abundant, and Pied Butcherbird, Yellow-throated Miners, Australian Raven, Australian Magpie and Black-faced Woodswallow more abundant, in sites dominated by *B. pertusa*.

The species richness of both vertebrates and plants was significantly greater at sites with low cover (<5%) of *B. pertusa* compared to sites with high cover (>5%). Within the birds, the diversity of some guilds (e.g. ground/understorey insectivores) was markedly lower in high cover sites. The richness of other guilds (e.g. granivores) did not differ, but there was a clear turnover in dominant species (Red-winged Parrot and Zebra Finch were abundant in sites with <5% *B. pertusa*, while Cockatiel and Galah were abundant in sites with >5%).

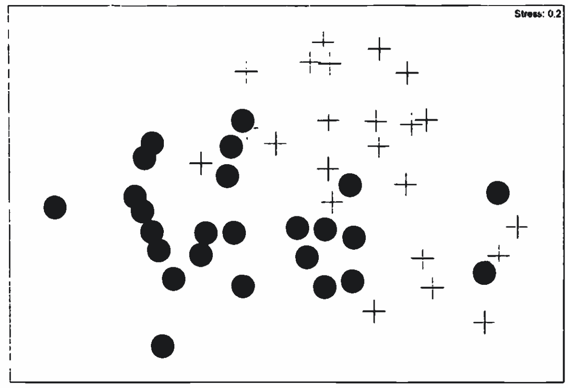


Figure 1. Two-dimensional ordination (multidimensional scaling) indicating the change in bird species composition between sites with <5% (solid circles) and >5% (crosses) *B. pertusa* cover.

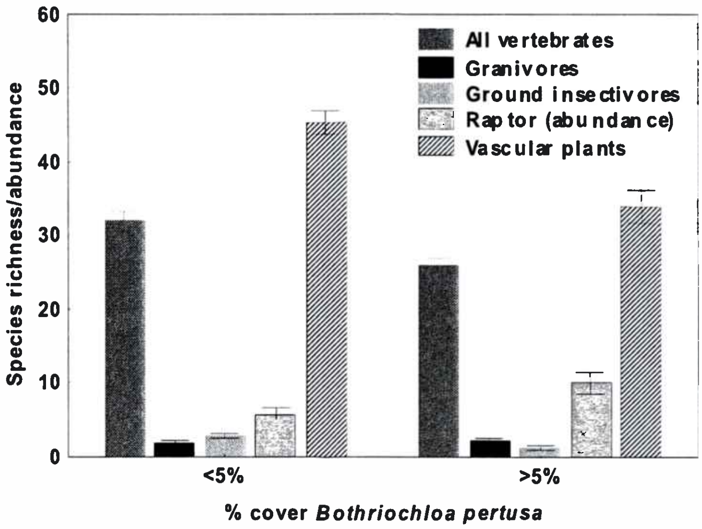


Figure 2. Mean richness or abundance (+/- s.e.) of selected fauna and flora groups at sites with <5% and >5% *B. pertusa* ground cover.

DISCUSSION

The implications of this study are to some extent self-evident – we must be careful about the context when discussing the relationship between land condition and biodiversity. At our sites, the relationship between biodiversity status and "land condition" was dependent on whether a high cover of *B. pertusa* was considered to indicate "good" or "poor" condition. When the condition of sites is assessed from a pastoral perspective the presence of perennial, productive and palatable introduced pasture grasses such as *Cenchrus ciliaris* and *Bothriochloa pertusa* are considered desirable, but this assessment ignores the substantial impacts of these introduced pastures on native biota. If conventional methods for monitoring land condition, including remotely-sensed cover-change analyses, are to be adapted as broader indicators of landscape health (including biodiversity status) in rangelands, then they must be sufficiently flexible to take into account the ecological differences between native and introduced perennial pastures.

ACKNOWLEDGEMENTS

We are grateful to a number of people who assisted with the fauna and flora sampling over the course of this project: Damian Milne (NT DIPE), Emily Bolitho, Jeanette Kemp and Justine Douglas (Qld EPA). The study was funded by Land and Water Australia and the Tropical Savannas CRC.

THE INFLUENCE OF DIFFERENT GRAZING STRATEGIES ON THE PATTERNS OF VERTEBRATE FAUNA IN A TROPICAL SAVANNA WOODLAND

Alex S. Kutt [1], *Alaric Fisher* [2] *and Peter O'Reagain* [3]

[1] Tropical Savannas Management CRC and EPA, PO Box 5391, Townsville, Qld 4810
[2] Tropical Savannas Management CRC and DIPE, PO Box 496, Palmerston, NT 0810
[3] Department of Primary Industries, PO Box 976, Charters Towers, Qld 4820

INTRODUCTION

The tropical savannas of northern Australian are characterised by high climatic variability, with corresponding impacts on annual resource availability. The native biota is adapted to these patterns, but variability in rainfall and forage production is a major challenge to the cattle industry. Despite this variability, many properties tend to set-stock, sometimes exceeding their 'safe' long-term carrying capacity and causing resource degradation. Typically, resource degradation refers to the impact on productivity and profitability of grazing enterprises, though the manner in which native fauna changes with different management strategies is a significant issue from a conservation perspective. In this paper we examine variation in the composition of the vertebrate fauna over a six-year period in a large grazing trial being conducted in tropical savanna woodlands in north-eastern Queensland.

METHODS

In 1997, a grazing trial was established on Wambiana Station (20° 34' S 146° 07' E) near Charters Towers in North Queensland, in order to examine ways of better managing for rainfall variability. The objective was to test, at a paddock scale, the relative impacts on resource condition and animal production of five grazing strategies – light stocking, heavy stocking, variable stocking, variable-SOI stocking and rotational spelling. The trial had a replicated design using ten, 100 ha paddocks, each with similar proportions of three land types dominated by open *Eucalyptus* and *Acacia* woodland.

In addition to the standard pasture condition assessments undertaken during the trial, sites for monitoring vertebrate fauna were established in 1998 to provide pre-treatment baseline data. Sixteen sites were sampled using standardised one-hectare quadrats, representing two land types (box *Eucalyptus brownii* and ironbark *E. melanophloia* open woodlands) in two replicates of four of the grazing treatments (heavy, light, variable, rotational). These sites, and an additional eight sites in box woodlands were re-sampled in 2003/4. Mammals, reptiles, birds, amphibians, ants, vascular plants, vegetation structure and other habitat attributes were recorded within each quadrat plot.

RESULTS

A total of 98 species comprising 64 birds, 20 reptiles, 4 amphibians and 10 mammals have been recorded to date within the grazing trial. Examination of the dry season bird sample indicates that the composition of the avifauna has changed markedly from the baseline to the resample (Figure 1). Species such as Rufous Whistler and Red-backed Fairy-wren were less abundant in the resample, and Weebill and Striated Pardalote more abundant.

The lower mean dissimilarity (Bray-Curtis index using both the baseline and resample scores) in the heavily grazed sites compared to the light and rotational and variable (category=mid) stocking treatments (Fig. 2) suggests the imposition of more conservative grazing regimes has resulted in a greater degree of change in the fauna composition. Some preliminary trends indicate that species that have declined across the trial since the baseline survey (e.g. fairy-wrens) were in fact still abundant in the lightly grazed treatments.

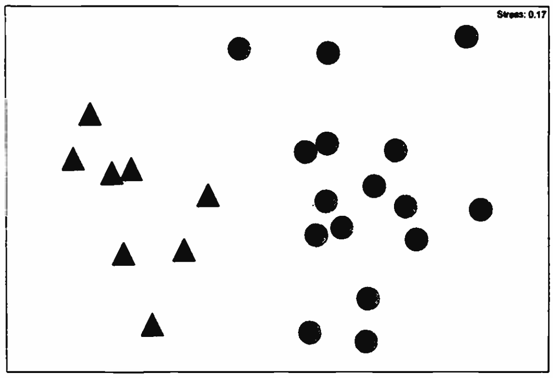


Figure 1. Two-dimensional ordination (multidimensional scaling) indicating the change in bird species composition (dry season sample only) between sample sites between the baseline survey (solid triangles) and the resample (grey circles) in the *Eucalyptus brownii* woodland.

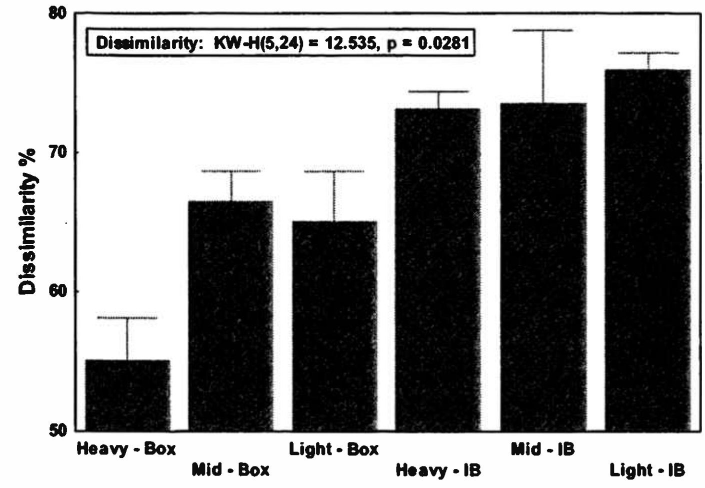


Figure 2. Mean compositional dissimilarity (Bray-Curtis) for each vegetation type and treatment using bird species composition (dry season sample only) data.

DISCUSSION

The pattern of change in the vertebrate fauna abundance and composition across the Wambiana grazing trials is likely due to the imposition of the grazing treatments, combined with climatic variation. However there are marked differences manifesting between the extreme and more moderate stocking strategies. The implication of this is that conservative grazing does have biodiversity benefit. These data also suggest that the local decline of some species may be useful indictors of management that is gradually impacting on native wildlife.

ACKNOWLEDGEMENTS

We are grateful to a number of people who assisted with the fauna and flora sampling over the course of this project: Damian Milne, Jenni Risler, Birgit Hallenstein, Jerome Petit (DIPE, NT), Eric Vanderduys, Sari Mangru, Stephanie Brown, Jeanette Kemp, Adam Tassicker and Zoe Case (EPA, Qld). The study was funded by Land and Water Australia and the Tropical Savannas CRC.

RELICT *MITIKA* WARRENS IN CENTRAL AUSTRALIA: IMPLICATIONS FOR FUTURE BIODIVERSITY AND LANDSCAPE FUNCTION

Jim Noble [1] *and Bill Low* [2]

[1] CSIRO Sustainable Ecosystems, GPO Box 284, Canberra, ACT 2601
[2] W.A Low Ecological Services, PO Box 3130, Alice Springs, NT 0871

INTRODUCTION

Prior to European pastoral settlement in the semi-arid and arid hinterland of Australia around 140 years ago, the *mitika* or burrowing bettong (*Bettongia lesueur*) had the widest mainland distribution of any of the native mammals (Finlayson 1958). The species had virtually disappeared from semi-arid eastern Australia by the end of the 19th century however in central Australia, *mitika* appeared to have survived much longer and senior *Pitjantjatjara* can recall hunting them with their parents up until the early 1950s. Today, wild populations remain extant only on islands off the NW coast of West Australia. Recent studies in extensive mulga (*Acacia aneura*) communities across semi-arid Australia have provided clear evidence of their past occupation in the form of distinctive warrens characterised by semi-circular perimeter mounds surrounding a partially exposed 'lens' of calcrete. The tendency for most of these relict warrens to be located in a mid-slope position (Fig. 1) suggested that these 'lenses' resulted from vadose calcrete being precipitated following evaporation of groundwater moving down the slope (Noble *et al.* 2001). Because of this relationship between *mitika* warrens and calcrete, it was hypothesised that the highest warren densities were likely to be found in landscapes containing predominately calcareous soils. This paper briefly summarises results from field surveys undertaken across contrasting land systems in the core central Australian region, especially in land systems containing extensive pedogenic calcrete.

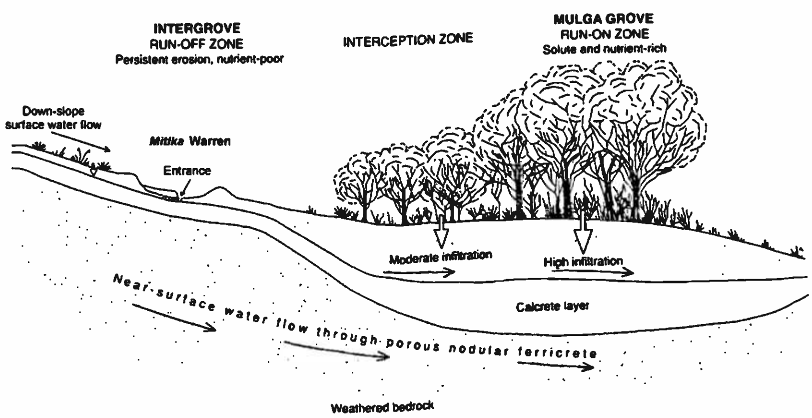


Figure 1. Topographic section of a banded mulga landscape showing the mid-slope position of a typical *mitika* warren (after Noble *et al.* 2001).

FIELD SURVEYS

The ability of the European rabbit (*Oryctolagus cuniculus*) to rapidly invade much of the Australian continent, particularly stony landscapes throughout the arid and semi-arid zones, was due to the availability of 'pre-fabricated' warrens produced by *mitika*. A major exercise involving the mapping and subsequent ripping of many of the warrens utilised by rabbits in the *Uluṟu–Kata Tjuṯa* National Park also provided a detailed insight into the putative distribution of *mitika* at a landscape scale prior to their local extinction. To further test the calcareous habitat x *mitika* warren hypothesis, several contrasting land systems were initially surveyed over a wide area. Subsequent surveys of *mitika* warrens in land systems selected on the basis of their contrasting geology were sampled for absolute density along replicate, randomly oriented transects using a wandering quarter technique. Warren position (using a global positioning system), warren dimensions, class (rated on size, definition and presence/absence of a calcrete 'lens'), habitat geology and associated vegetation were all recorded. Some representative data are shown in Table 1.

DISCUSSION AND CONCLUSIONS

Continuing field surveys in central Australia have clearly demonstrated that the distribution of relict *mitika* warrens, both at land system and landscape scales, is far from random. Like many of the perennial plants, *mitika* warrens exhibited contagious distributional patterns that, in turn were strongly influenced by local edaphic and hydrologic factors. Landscape function analyses undertaken in *Uluru–Kata Tjuta* National Park also underlined the fundamental role these warrens have played as obstruction elements trapping surface soil nutrients, organic matter and seeds and thereby enhancing local flora and subsequently fauna biodiversity. Soil inversion resulting in calcareous subsoil being deposited on the surface of the perimeter mound also led to the establishment of localised patches of highly palatable grasses, especially species of *Enneapogon* such as those found adjacent to *mitika* warrens on terraces at "Deep Well" Station SE of Alice Springs. Future rabbit control measures should utilise non-destructive techniques in order to maintain future integrity of these landscape features. Recent cross-cultural workshops (Gillen *et al.* 2000) have identified the high priority given by the *Mutitjulu* to the ultimate re-introduction of *mitika* into appropriate habitats. Hopefully the information gained from these studies can be utilised during the site selection process should such *mitika* re-introductions be undertaken in the future.

Table 1. *Mitika* warren data for contrasting land systems in central Australia.

Location	Land System	No. Sampled	Modal Class	Mean Diameter (m)	Mean Distance (m)	Absolute Density (100 sq m)
"Erldunda"	Lindavale	56	3	17.3	136.2	0.015
"Erldunda"	Ebenezer	15	4	20.3	153.4	0.004
"Deep Well"	Allua	24	4	17.0	62.0	0.026
Kata Tjuta N.P.	Gillen	14	2	21.9	not collected	n.c.
"Curtin Springs"	Lindavale	8	1	30.4	n.c.	n.c.
"Owen Springs"	Muller	7	2	15.0	447.8	< 0.001
Finke Gorge N.P.	Krichauff	6	2	14.0	n.c.	n.c.
"Mt Skinner"	Woolla	5	2	26.7	n.c.	n.c.

REFERENCES

Finlayson, H.H. (1958). On central Australian mammals (with notice of related species from adjacent tracts). Part III - the Potoroinae. *Rec. S. Aust. Mus.* 13: 235-302.

Gillen, J.S., Hamilton, R., Low, W.A. and Creagh, C. (Eds) (2000). 'Biodiversity and the Re-introduction of native fauna at *Uluru-Kata Tjuta* National Park.' Bureau of Rural Sciences, Canberra.

Noble, J.C., Gillen, J., Jacobson, G., Low, W.A., Miller, C. and *Mutitjulu* Community (2001). The potential for degradation of landscape function and cultural values following the extinction of *mitika* (*Bettongia lesueur*) in Central Australia. *In* 'Land Degradation in Australia.' (Ed. A. Conacher) pp. 71-89. Kluwer Scientific Publications, Dordrecht.

MONITORING MULGA LAND CHANGE: 12 YEARS LATER

Manda Page and R.J.S. Beeton

School of Natural & Rural Systems Management, University of Queensland Gatton, Qld 4345

INTRODUCTION

The Mulga Land Biogeographic region represents a significant proportion of Australia's rangelands and is a microcosm of the biodiversity and production related issues faced by rangeland managers world wide. The Mulga Lands have undergone significant changes in relation to productivity and biodiversity in the past 200 years. These ecosystems are serendipitous in nature, a phenomenon best described by state and transition models. Figure 1 diagrammatically represents the factors reported in the literature as influencing system dynamics. This figure highlights that apart from social, economic and cultural factors, grazing pressure, climate (particularly rainfall) and woody shrub densities are the main drivers of historic vegetation change in the Mulga Lands. This study investigates the contemporary effects of these factors in a 12 year monitoring program undertaken in two Mulga Land communities in SW Queensland. The experimental design includes a manipulation of grazing regimes and woody shrub densities.

This study was undertaken on Currawinya National Park, situated in south west Queensland (28° 25'S, 144° 30'E). The area was proclaimed a National Park in 1992 following 150 years as a sheep station. Rainfall (331mm/yr) is highly unpredictable both within and between years. The area was considered degraded at the time of declaration with evidence of soil erosion, palatable perennial grass extinction and increased density of native woody shrubs. Vegetation monitoring under three grazing regimes (off-park: feral, native and domestic grazing, on-park: feral and native grazing, exclosures: no mammalian grazing pressure) began in 1992. In 1994 shrubs were removed from matched paired sites and included in the monitoring program. The two vegetation communities measured were Sandplain Mulga and Dunefields. Annual rainfall over the study period ranged from 72 mm (2002) to 582 mm (2000) with below average rainfall in 1992, 1993, 1994, 1996, 2001, 2002 and 2003.

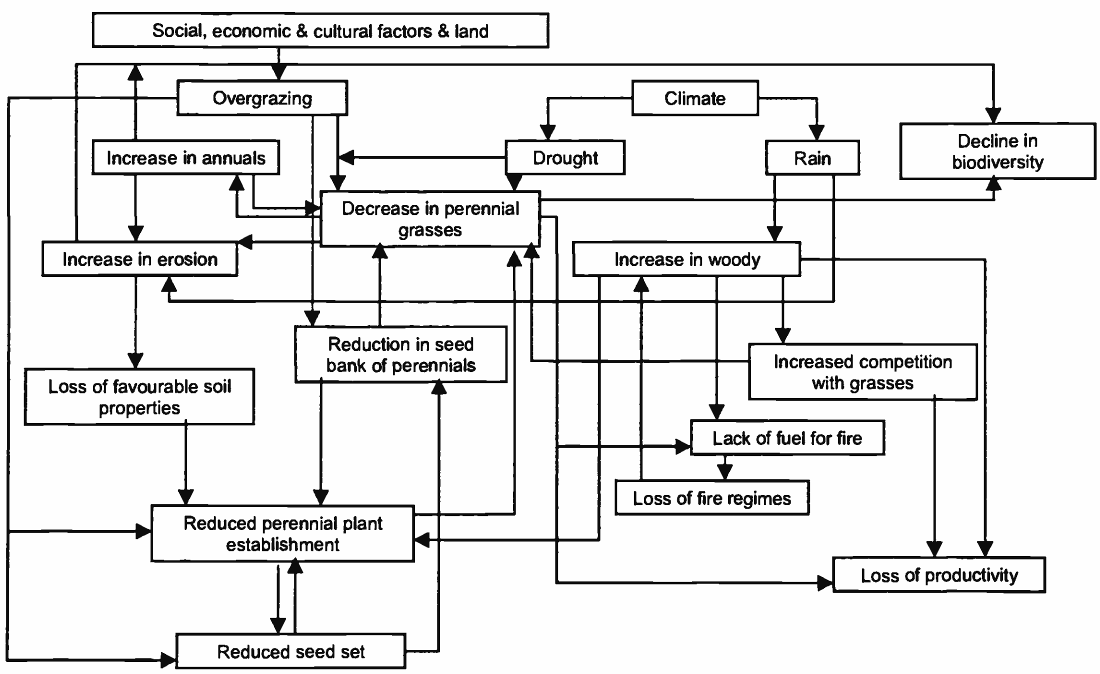


Figure 1. Vegetation change factors in the Mulga Lands.

RESULTS

Figure 2 is an example of the results from this study. This figure shows the mean percentage cover of grasses over the three grazing regimes, with woody shrub present and absent, over the 12 years for each vegetation type. Perennial grass cover is a good indicator to assess both production and conservation goals (Figure 1). The results indicate that the main driver in these systems is the amount and timing of rainfall. However, total removal of mammalian grazing pressure resulted in significant increases in the cover and diversity of perennial grasses. Simply removing sheep only results in significant differences following good summer rainfall. The success of woody shrub control is negatively correlated with grazing pressure but if grazing pressure is present, the result is a higher density of shrubs.

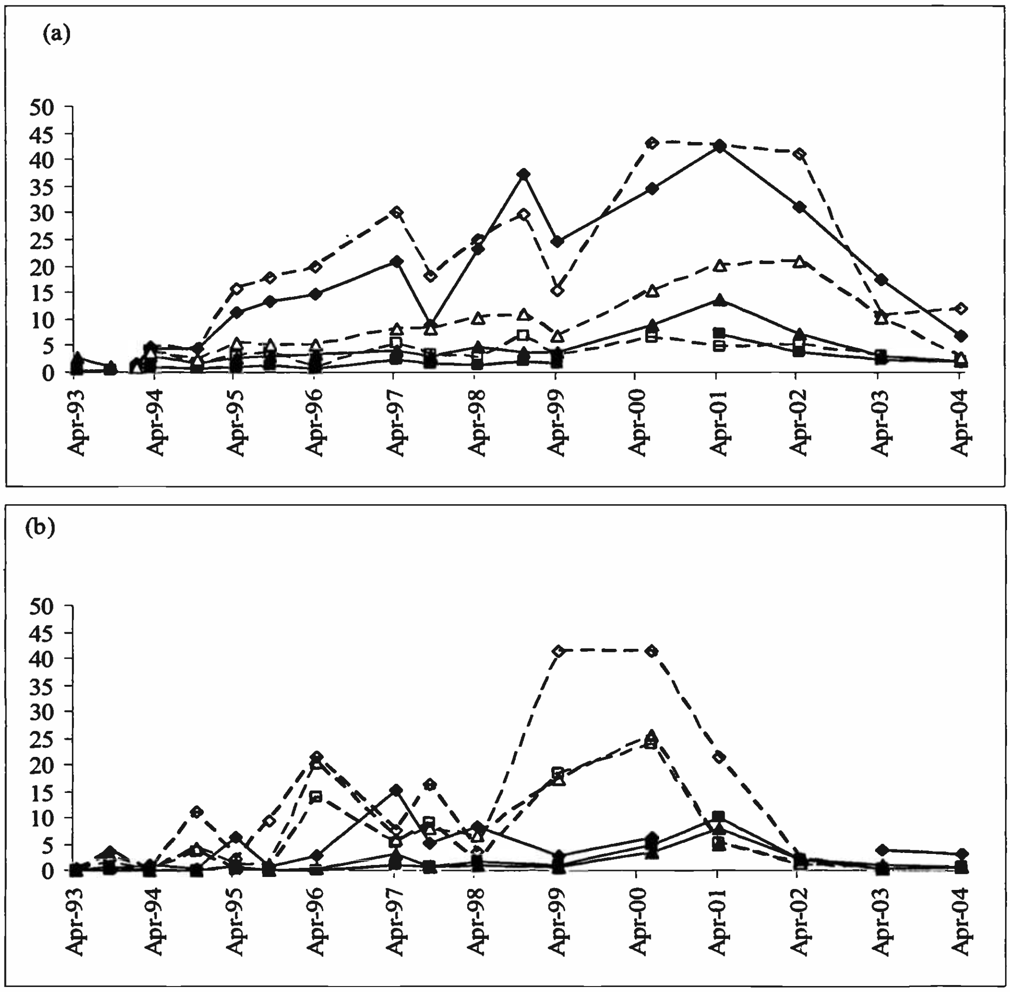


Figure 2. Mean percent cover of perennial grasses in (a) Sandplain Mulga and (b) Dunefields between 1993 and 2004 under three grazing regimes (♦exclosure, ▲on-park, ■off-park) and with woody shrubs present (solid line) and absent (broken line).

DISCUSSION

Firstly, from a production point of view, simply reducing stock numbers will not result in significant long term improvement unless coupled with good summer rainfall. The main lesson being that without reducing grazing pressure, other strategies such as woody shrub control are a waste of time. Secondly, the declaration of a National Park followed by simply removing domestic stock is not enough for these areas to be restored and conservation objectives realized. As managers cannot manipulate the timing or amount of rainfall, this study indicates that total grazing pressure must be managed in order to gain the greatest production and restoration results.

THE DISPERSAL, IMPACT AND MANAGEMENT OF BUFFEL GRASS (*CENCHRUS CILIARIS*) IN CENTRAL AUSTRALIA

Helen Puckey [1], Colleen O'Malley [2], Michelle Waycott [3] and Margaret Friedel [4]

[1] DIPE, Parks and Wildlife, PO Box 2130, Alice Springs NT 0871. helen.puckey@nt.gov.au
[2] Threatened Species Network, PO Box 2796, Alice Springs NT 0871. tsnnt@ozemail.com.au
[3] James Cook University, Townsville QLD 4811. michelle.waycott@jcu.edu.au
[4] CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs NT 0871. margaret.friedel@csiro.au

INTRODUCTION

Buffel grass (*Cenchrus ciliaris*) is a perennial tussock grass native to Africa, India and Asia with a wide naturalized distribution in Australia. In central Australia it has spread widely from introduction points and now occurs extensively across all land tenures. In the early years of establishment, buffel was generally viewed as a desirable species for land rehabilitation and pastoralism in the region. In recent years there has been growing concern about its impacts on biodiversity in conservation areas.

Under the new Desert Knowledge CRC, a collaborative project involving CSIRO, James Cook University, Parks and Wildlife and the Threatened Species Network has been established with the aim of providing land managers and policy makers with reliable information and the appropriate tools to maximize any benefits associated with buffel while minimizing the adverse impacts. The project has three main objectives; (1) to identify the impacts of buffel on biodiversity in the Alice Springs region (particularly invertebrates and ground cover vegetation), (2) to identify buffel dispersal patterns and mechanisms in different cultivars using landscape genetics techniques, and (3) to evaluate the use of aerial survey as a method for detection and mapping of buffel spread in areas of conservation value.

IDENTIFYING IMPACTS OF BUFFEL ON BIODIVERSITY

Buffel is now perceived as a major threat to those managing for biodiversity values because of its ability to modify vegetation structure and reduce species diversity. Threats include increased competition with native vegetation for nutrients, water and light, allelopathic alteration of soil properties that inhibit germination and growth of other plants, alteration of ecosystem processes such as fire regime and succession, and displacement of native animals through changes to habitat structure and composition (Butler and Fairfax 2003, Miller 2003, Best 1998, Cheam 1984).

The present study aims to test whether buffel colonization reduces the diversity of ant, small reptile and short lived plant communities in the Arunta Block hill slope communities north of Alice Springs, and to examine the recovery potential of those same communities once buffel is removed from the system.

IDENTIFYING DISPERSAL PATTERNS & MECHANISMS IN DIFFERENT CULTIVARS

Observations of areas of dense buffel along roadsides and watercourses, coupled with the existence of extensive areas dominated by buffel, have lead to suggestions that range expansion is a two-step process, involving 'infiltration' along road and/or riparian pathways followed by 'infill' of surrounding areas. However, such an interpretation confounds the separate processes of dispersal and establishment, and may be misleading or incomplete. The factors behind the observed variability in population dynamics after introduction, from failure to establish persistent populations, through limited establishment over years or decades followed by sudden irruption, to immediate establishment and rapid spread, need to be explicitly identified as a starting point for managing or controlling buffel dispersal.

Landscape genetic techniques using Inter-Simple Sequence Repeat markers will be applied to reveal patterns of dispersal and develop a model of dispersal processes. Since buffel usually produces seed that are genetically identical to the maternal plant, these molecular tools discriminate between individual varieties. When used in conjunction with records of the original spread of seeds, these techniques allow both improved reconstruction of subsequent dispersal and the identification of differences in the ecology of varieties.

EVALUATING AERIAL SURVEY FOR DETECTION AND MAPPING

The extensive spread of buffel across large areas of conservation land prohibits conventional methods of mapping from the ground. It also means that new outbreaks are difficult to detect. Park managers need appropriate weed mapping tools for effective planning and management of buffel control on park. As part of the current project, aerial survey will be trialed as a tool for mapping buffel.

The two main objectives are:

1. To trial the efficacy of aerial survey in mapping the distribution of buffel on park, and
2. To trial the efficacy of aerial survey in detecting early infestations of buffel on park.

The aerial survey will be flown in a helicopter at a constant speed and altitude and buffel percentage cover will be visually estimated by two observers along flight transects. The data recorder will run real time mapping software on a laptop connected to a GPS which will attribute a spatial point when each observation is made. The point data collected from flight transects will be used to characterize the distribution of buffel over the entire area via probabilistic modeling of the data.

FUTURE DIRECTIONS

The research outcomes will support the development of better policy and practice for the management and use of buffel grass in a variety of settings in central Australia. The knowledge gained will underpin subsequent investigation of the socio-economic impacts of buffel grass spread on tourism, pastoralism and bush-food industries and also the development of management systems to control the spread of buffel into susceptible or high conservation value areas.

REFERENCES

Best, R. (1998). Honors Thesis: The effect of introduced Buffel (*Cenchrus ciliaris* L., Poaceae) on the diversity and abundance of invertebrates in semi-arid central Australia. Northern Territory University.

Butler, D.W. and Fairfax, R.J. (2003). Buffel and fire in a Gidgee and Brigalow woodland: a case study from central Queensland. *Ecological Man. and Rest.* 4: 120-125.

Cheam, A.H. (1984). Allelopathy in Buffel (*Cenchrus ciliaris* L.) Part I Influence of Buffel association on calotrope (*Calotropis procera* (Ait) W.T. Ait). *Australian Weeds* 3: 133-136.

Miller, G. (2003). Honors Thesis: Ecological impacts of Buffel (*Cenchrus ciliaris* L.) invasion in central Australia – does field evidence support a fire-invasion feedback? University of New South Wales.

DELETERIOUS EFFECTS OF GRAZING ON THE BIODIVERSITY OF BREAKAWAY FOOTSLOPE THICKETS

Jeff Richardson [1] and Hugh Pringle [2]

[1] Dept. CALM, PO Box 51, Wanneroo WA 6946
[2] CMAE, Dept. of Agriculture, PO Box 417, Kalgoorlie WA 6430

ABSTRACT

This study compared habitat structure and species richness between grazed and ungrazed breakaway footslope thickets in the arid shrublands of Western Australia. Mobile or more transient habitat variables (ground cover, leaf litter cover and depth) were significantly less in the grazed area. Similarly, there were less frogs and lizards in the grazed sites. We interpret these results in the context of the biology of the vertebrates and conclude that reduction of leaf litter may be responsible for the patterns. Ongoing sampling within the broader study will be used to test this hypothesis.

INTRODUCTION

There has been considerable work done on examining the influence of grazing on biodiversity (e.g. Woinarski and Ash 2002, Jansen and Healey 2003). But there have been few opportunities to develop before-after-control-impact studies on these effects. One such study is being developed in the Goldfields of WA. We present preliminary results comparing vegetation structure and terrestrial vertebrates of breakaway footslopes in a grazed and ungrazed area.

Breakaway footslope thickets appear intermittently in surface water run-on areas in recesses at the base of breakaways. In contrast to the rest of the vegetation on the footslope they tend to have large trees, several layers of vegetation, deep leaf litter, and characteristically denser and more species rich vegetation.

METHODS

In July and November 2003, we sampled five replicate breakaway thickets in a grazed and an ungrazed area on Cashmere Downs pastoral station in the WA Goldfields (28°58'S; 119°34'E). The grazed and ungrazed breakaways are approximately forty kilometres apart. The grazed sites have been grazed certainly since the mid-1960's and possibly as early as the 1930s. The ungrazed areas were too distant from water to allow continued grazing, though there was the occasional dung pile and cattle track and on the breakaway a single pile of goat dung.

Leaf litter cover and depth, area of rock and area of logs were sampled in five 1 sq m quadrats placed along the longest axis of each thicket. A 2 metre wide belt transect (10 metres long) was used to sample density and number of perennial species in three strata: <1 metre, between 1 and 2 metres and >2 metres. Vertebrates were sampled from a single pitfall line (with two buckets; called an array) over 182 array nights. Invertebrates were also sampled but the results are not reported here.

RESULTS AND DISCUSSION

Grazing altered the less resilient habitat components: there was less leaf litter (both depth and cover) and vegetation at the ground layer (and consequently more bare ground) in the grazed sites. Habitat attributes such as rocks and logs, and perennial vegetation density in the mid and upper strata did not differ between treatments. The total number of plant species differed between treatments, but did not differ significantly between strata (Table 1).

Table 1: Habitat and perennial vegetation species variables from grazed and ungrazed sites. Those in bold face are significant. Means (±SE)

	Ungrazed	Grazed	Sig. Level
Area Bare ground[1]	**1.6(.22)**	**2.28(.23)**	**0.02**
Area rock[1]	0.96(.07)	1.12(.07)	0.1
Area leaf[1]	**4.72(.12)**	**4.36(.14)**	**0.03**
Area log[1]	1.24(.09)	1.28(.15)	0.74
Leaf Depth[1]	**2.28(.25)**	**1.64(.11)**	**0.04**
Total Number species[2]	**12(1.79)**	**5.4(2.1)**	**0.04**
#species < 1 metre[2]	7.8(1.39)	3.4(1.9)	0.097
# species 1-2 metres[2]	1.8(.73)	0.4(.24)	0.105
# species >2 metres[2]	1.8(0.5)	1.6(.24)	0.724
Density < 1metres[2]	**34.6(6.4)**	**9.8(6.1)**	**0.023**
Density1-2 metres[2]	2.2(0.97)	0.8(0.58)	0.251
Density >2[2]	3(1.14)	2.2(0.58)	0.55

[1] Kruskal-Wallis Test; [2] ANOVA

It rained on both sampling occasions. While this allowed frogs to be active, the summer rain bought with it a large temperature drop. This may have influenced our fauna results, but as the sites experienced similar rainfall, some patterns are evident. The ungrazed thickets had a higher number of vertebrate species than the grazed thickets (7 versus 2). Both species found in the grazed sites were also found in the ungrazed sites. The frog *Pseudophyrne occidentalis* was more common in the ungrazed area (31 vs 1) and was found in all five of the ungrazed sites but only one of the grazed sites.

Grazing is known to influence frog (Jansen and Healey 2003) and reptile (Woinarski and Ash 2002) assemblages. However, while the proximate cause (habitat alteration) is known, the ultimate reasons (specific habitat components) are difficult to determine. Changes in substrate and canopy cover may explain the reptile assemblage at a local scale (Smith 1996). In this study, changes in substrate, particularly leaf litter, may have driven our results. The skink *Lerista muelleri* (only found at the ungrazed sites) is fossorial and may require deep leaf litter for foraging its invertebrate prey. Likewise, *P. occidentalis* was found in all ungrazed sites and only a single grazed site. Congeners (e.g. *P. guentheri*) use dead leaves as diurnal habitat.

These findings are part of a larger study that will ultimately contain four treatments ((i) Never grazed and never to be grazed; (ii) released from grazing; (iii) ungrazed but soon to be grazed and (iv) grazed with continued grazing) in three vegetation communities (thickets at breakaway footslopes, chenopod and mulga communities). The results above are from treatments (iii) and (iv). Ongoing comparisons, particularly monitoring the breakaway thickets after they are grazed, should allow further understanding of the patterns found here.

ACKNOWLEDGEMENTS

We would like to thank the lessees of Cashmere Downs (David and Vicki McQuie) for access to the sites, helping install the pitfalls, their interest in the project, hospitality and shelter from the storms. We would also like to thank the EMU team (Sally Black, Annabelle Bushell and PJ Waddell) for assistance in data collection and data entry.

REFERENCES

Jansen, A. and Healey, M. (2003). Frog communities and wetland condition: relationships with grazing by domestic livestock along an Australian floodplain river. *Biol. Cons.* 109(2): 207-219.

Smith, G.R. (1996) Habitat use and fidelity in the striped lizard *Sceloporus virgatus*. *Am. Midl. Nat.* 135: 68-80.

Woinarski, J.C.Z and Ash, A.J. (2002). Responses of vertebrates to pastoralism, military land use and landscape position in an Australian tropical savanna. *Austral Ecol.* 27: 311-323.

RAINFALL-DRIVEN EPISODIC FLOOD EVENTS: ARE THEY A MAJOR FACTOR IN MOULDING AUSTRALIAN ARID LAND VEGETATION

M.E. Westbrooke and S K. Florentine

School of Science and Engineering, Centre for Environmental Management,
University of Ballarat, PO Box 663, Ballarat VIC 3350

ABSTRACT

Arid vegetation is subjected to more or less frequent fire, drought, sporadic flooding events and grazing. Whilst fire, drought and grazing have been the subject of considerable research, little is known of the impact of flooding in arid environments. We examined the effects of a flooding event, and its interaction with fire and grazing on moulding the arid vegetation. Number of species per area dropped (from 12 to 6 per 25 sq m), while average cover increased (from 27 to 83 %). This increase in cover was greater when plots had been burnt than when not burnt. Vegetation in plots left open to grazing by vertebrates differed from fenced plots. The exotic *Nicotiana glauca* was found associated with flooded unfenced plots. Major flooding events not only trigger native species' germination and recruitment but also create an avenue for exotic species to invade.

INTRODUCTION

There is a widely held view that Australian arid zone vegetation is shaped by erratically occurring high rainfall events (Stafford-Smith & Morton 1990). Such events are critical in triggering regeneration of long-lived perennials (Griffin & Friedel 1985). Noble (1986) considered the chances of these events occurring in different situations and determined that only on roadsides was there any real probability of these conditions co-occurring. Even on roadsides he estimated the chance as one in 250 years. Whilst fire, drought and grazing have been the subject of considerable research, little is known of the impact of flooding in arid environments and its interaction with other impacts. During February 1997, an extreme rainfall event caused flooding in the Olary Creek and inundated its flood plain. One branch of the creek created a terminal lake within mallee vegetation on Nagaela Station, far western New South Wales. The flood path of Olary Creek and this terminal lake provide an opportunity to study the importance of rainfall-driven flood events in shaping vegetation in arid environments. These sporadic events may have played a major role in determining Australian arid-zone vegetation. Our main objective was to evaluate the relative importance of fire, flooding and grazing on native vegetation by placing pairs of permanent plots within vegetation that had experienced different combinations of fire and flooding.

METHODS

To assess the relative impact of flood, fire and grazing, permanent 25 x 25 sq m plots were established in September 1999, after the flooding (February 1997) and fire (December 1996) events. The permanently marked plots were placed in pairs in areas that had one of the following histories: (i) Not flooded, not burnt (n = 2); (ii) Flooded, not burnt (n = 2); (iii) Not flooded, burnt (n = 2); (iv) Flooded, burnt (n = 2). One of the plots in the pair was left unfenced while the other was fenced to prevent grazing by vertebrate animals. Detailed vegetation data were collected in October 2000 and October 2002. The objective was to monitor recovery of vegetation following different combinations of impact. Each plot was further divided into 5 x 5 sq m subplots. Within each of these sub-plots, species were recorded along with a cover estimate based on the Braun-Blanquet cover scale. The data were analysed with both univariate and multivariate methods.

RESULTS

Number of species per area dropped (from 12 to 6 per 25 sq m), while average cover increased (from 27 to 83 %). This increase in cover was greater when plots had been burnt than when not burnt.

Vegetation in plots left open to grazing by vertebrates differed from fenced plots, but the amount of variation explained was small compared with flooding and the change over time (Table 1). Twenty-seven native species from 13 families were recorded both in the enclosed and open plots located on the flooded area. Further, eleven exotic species from five families were recorded in the flooded (both enclosed and open) plots over the study period. The shrub *N. glauca* invaded a large part of the lake and extended into the surrounding mallee shrubland. In September 1998, no *N. glauca* was found across flooded and control plots. In October 2000, 24 and 12 *N. glauca* seedlings per ha were recorded from flooded unfenced and fenced plots respectively. This number had significantly (P = 0.0001) increased by October 2002, when 756 and 468 per ha were recorded in the flooded unfenced and fenced plots respectively. *N. glauca* was not recorded from control (unflooded) fenced and unfenced plots.

Table 1. Decomposition of the explainable variation according to four different partial Redundancy Analysis

ENVIRONMENTAL VARIABLES	Co-variables	Explained variance (%)	F-Value	***P- Value***	Permutation blocks defined by: (samples per block)
A: Fire/No fire	B, C, D	2.0	0.853	0.5106	A, B & C (4)
B: Flooded/Not flooded	A, C, D	12.9	5.619	0.0002	A, C & D (4)
C: 2000/2002	A, B, D	19.4	8.731	0.0008	D & plot id (2)
D: Open/Exclosed	A, B, C	3.5	1.596	0.0284	C & plot id (2)

DISCUSSION

It is well known that annual plant species respond strongly to annual variation in rainfall. How botanical composition responds to high rainfall-driven flooding events however has received little attention, mainly because such high rainfall-driven flooding events have been ignored as "once in a lifetime". No serious attempt has been made to explore these rare opportunities to understand the effects and response of native and exotic species in arid landscapes in Australia and other parts of the world. To look at the plant response to this rare flooding event in the context of the theory of water availability effects on arid land plant species, it is essential to consider the 1997 high rainfall-driven episodic flooding event. Our study not only shows that a significant number of annuals irrupted in response to this rainfall, but perennial species also respond more positively in the flooded plots than unflooded plots. The 1997 rare episodic flooding event not only facilitated native annual and perennial species recruitment but also brought exotic plant species into this newly created lake. One exotic species, *N. glauca,* is a major concern. In conclusion, these rare flooding events have created suitable conditions for annuals and more importantly, long lived perennial species. It seems that *N. glauca* is potentially a serious weed in arid catchments such as Olary Creek. Our study suggests that *N. glauca* tree density is significantly higher in the open flooded plots where grazing has eliminated competition from pre-existing shrub and grass species. The knowledge gained from this study would contribute to improved management strategies for arid land vegetation.

ACKNOWLEDGEMENTS

We would like to acknowledge the support of Per Milberg in providing statistical help and Marion O'Keefe, Mark Irvin, and Brock Baker for field assistance. The University of Ballarat provided financial support for this study.

REFERENCES

Stafford-Smith, D.M. and Morton, S.R. (1990). A framework for the ecology of arid Australia. *Journal of Arid Environments* 18: 255-278.

Griffin, G.F. and Friedel, M.H. (1985). Discontinuous change in central Australia: some implications of major ecological events for land management. *Journal of Arid Environments* 9: 63-80.

Noble, I.R. (1986). The dynamics of range ecosystems. In *Rangelands: a Resource Under Siege.* Proceedings of the Second International Rangeland Congress.

Multiple Use & Multiple Users
(Poster Group Six)

AUSTRALIA'S RANGELANDS: ANALYSING NATURAL RESOURCES, PATTERNS OF USE AND COMMUNITY ASSETS

R. Donohue, M. Hill, J. Holloway, P. Houlder, R. Lesslie, J. Smith and R. Thackway

Bureau of Rural Sciences, GPO Box 858, Canberra, ACT 2601

INTRODUCTION

Alternative land management options for the rangelands have important implications for Australia's natural resources - and the communities and industries that depend on their use. The Bureau of Rural Sciences is working to improve our understanding of uses of the natural resources of the rangelands, in particular to:

- identify and locate key natural resource and primary production assets,
- explore tensions between alternative claims on the natural resource base, and
- consider how trade-offs in the use of these assets may be investigated.

RANGELAND ASSETS

The first stage in the assessment involved development of a series of spatial profiles describing rangeland assets. The datasets on which these profiles are based were drawn from a wide range of sources including the Australian Bureau of Statistics and the National Land and Water Resources Audit. These profiles describe the natural resource base (physical environmental and biological assets), industry and community assets and threatening processes (see definitions below). A review of natural resource management issues facing the rangelands (e.g. National Land and Water Resources Audit 2001) assisted profile development and highlighted information gaps.

Natural resource base	Biophysical assets (actual and potential) supplied by nature enabling production of goods and services – including conservation.
Production base	The management of resources to produce goods and services.
Threatening processes	Processes that threaten sustainability of natural resources and production.

MULTI-CRITERIA EVALUATION

The profiles of rangeland assets formed a database for a spatial analysis of the tensions between alternative uses and their claims on natural resources. The Bureau of Rural Sciences has been utilizing decision aids such as ASSESS (Hill *et al.* 2004) for multi-criteria decision analysis (MCDA) in the Department of Agriculture, Fisheries and Forestry policy environment for a number of years. ASSESS provides a GIS-based interface enabling the simple spatial association of data layers ranked for developing output scenarios that may be constructed from different user viewpoints.

A multi-criteria decision analysis approach provides for:

- simple linear addition and combination of data layers,
- balance between evidence-based science and soft systems approaches to decision-making,
- flexible exploration of relationships between biophysical, economic and social phenomena.

The analysis procedure involves six key steps; the final two must be iterative.

1. Define problem and decision criteria.
2. Identify variables that influence decision criteria (biophysical, economic, social).
3. Assemble data inputs and establish relative rating.
4. Design operations and functions for synthesis.
5. Develop viewpoint profiles with clients, interest groups.
6. Workshop the results, develop consensus view / redefine problem.

Tensions between alternative claims on natural resources are analysed and expressed in terms of the spatial interaction between those resources, production values, and threatening processes (Figs. 1 & 2).

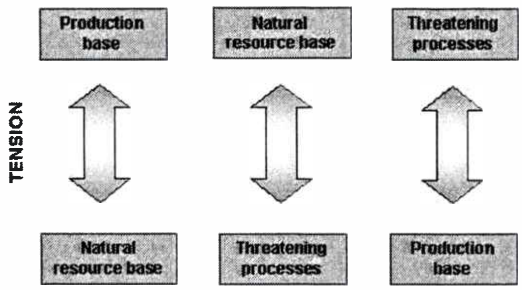


Figure 1. Framework for analysing alternative claims on the natural resource base.

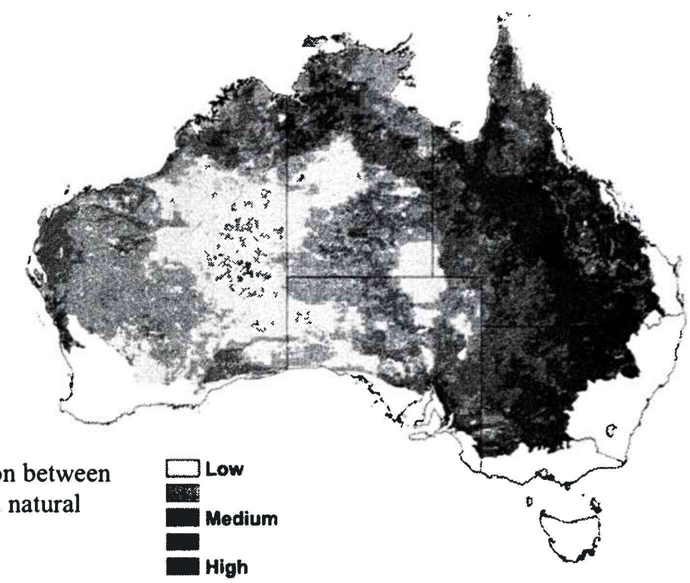


Figure 2. Illustrative index of tension among different claims on natural resources in the rangelands

OUTCOMES

It is anticipated that this MCDA-based approach will help:

- identify key issues and regions for investigation and information gaps in the rangelands,
- guide the development of more detailed investigations into rangeland issues,
- inform policy development for the rangelands, including ACRIS, and
- scope alternative landscape futures.

ACKNOWLEDGEMENTS

This project was funded by the Natural Heritage Trust through the Natural Resources Management Business Unit of the Department of Agriculture, Fisheries and Forestry. The Department of the Environment and Heritage is thanked for expert advice and key data inputs.

REFERENCES

Hill, M.J., Braaten, R., Lees, B., Veitch, S.M. and Sharma, S. (2004). Multi-criteria decision analysis in spatial decision support: the ASSESS analytic hierarchy process and the role of quantitative methods and spatially explicit analysis. *Environmental Modelling and Software*, (in press).

National Land and Water Resources Audit (2001). Rangelands – Tracking Changes; Australian Collaborative Rangeland Information System. National Land and Water Resources, Canberra.

BALANCING CONSERVATION AND PRODUCTION IN THE WESTERN DIVISION THROUGH ENTERPRISE BASED CONSERVATION

T. Ferraro and R. Shepherd

WEST 2000 Plus, PO Box 1840, Dubbo, NSW 2830

BACKGROUND

Despite increasing demand for landholders to place a higher priority on managing for conservation outcomes, it has not typically been economically viable for landholders to actively conserve part or all of their properties specifically for nature conservation.

WEST 2000 Plus has developed a five year pilot Enterprise Based Conservation program that provides an innovative and practical method to deliver financial incentives to Western Division landholders to balance conservation and production outcomes.

Ten properties are participating in the five-year pilot program, with projects located across the Western Division. Over 65,000 hectares will be managed for conservation outcomes, with individual project sizes ranging from 320 hectares to 23,000 hectares. Landholders will be paid an annual incentive to manage either all or part of their property specifically for conservation. The total cost of the project over five years, including annual payments and on-ground infrastructure, totals less than $3 per hectare per year.

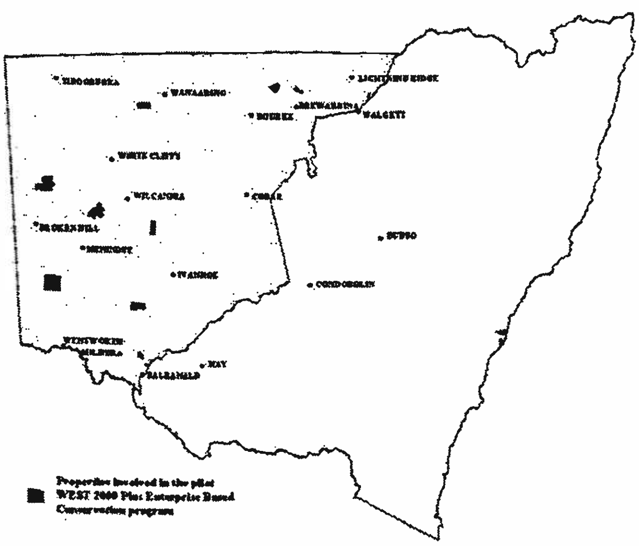


Figure 1. Location of properties in the Western Division participating in the WEST 2000 Plus Enterprise Based Conservation program.

MANAGEMENT ACTIVITIES

Rather than simply removing domestic stock and 'locking up' country, the program is based on achieving conservation outcomes though active and adaptive management. This will include reduction of total grazing pressure, control of pest animals, control of noxious weeds and reintroduction of fire. In some cases limited grazing by domestic stock will be permitted. The successful completion of these agreed conservation-based management activities forms the basis of landholders receiving a series of annual payments.

SELECTION PROCESS

Expressions of Interest lodged by landholders were shortlisted by an independent assessment panel. Shortlisted projects then submitted a competitive tender for funding. The final selection of projects was based on the natural features of the site as determined by a Biodiversity Benefits Index and expert knowledge, the proposed conservation outcomes of the project and the cost effectiveness of the proposal.

ISSUES ADDRESSED WITHIN THE PROGRAM

The landholders involved in the pilot program are following two management models. One model involves removing domestic stock and actively managing the area for conservation outcomes. A total of approximately 42,000 hectares will be managed under this model. The second model will see grazing by domestic stock continuing, with the grazing pressure managed to ensure that an agreed groundcover level (40 per cent) is retained, regardless of seasonal conditions. Approximately 26,000 hectares will be managed in this manner.

The individual projects address natural resource management issues, including the conservation of European and Aboriginal cultural heritage values, maintenance of threatened species and their habitats, improved river bank stability through the management of stock along riverine corridors, and large scale management of total grazing pressure to maintain agreed levels of groundcover. Threatened fauna species such as the Malleefowl (*Leipoa ocellata*) and Pink Cockatoo (*Cacatua leadbeateri*), and the endangered ecological community *Acacia loderi* shrublands are being protected under this program.

ADVANTAGES OF THIS METHOD OF CONSERVATION

This approach recognises that prevention is better than a cure – conserving existing habitat delivers better environmental outcomes and is more cost effective than rehabilitating degraded systems. Promoting conservation as a viable alternative landuse allows landholders to diversify their income and enhances property sustainability and viability. Landholders remain the primary managers of the land, thereby maintaining the accumulated land management knowledge and skills. Paying landholders to manage for conservation allows families to remain within rural communities and continue to support rural services.

CASE STUDIES

The Beven families, Sturts Meadows Station

Located north of Broken Hill, the Beven families will be managing 5500 hectares under this program. This is the only parcel of land that is formally managed for conservation within the Barrier Ranges. The area features the spectacular Bijerkerno Gorge, historic tin mine sites, and uncommon flora species. The conservation area will remain destocked, feral animals will be controlled, and the regeneration of the plant base will be monitored. Restoration works have been undertaken on the old cookhouse chimney and baker's bread oven at the historic tin mine site.

'Our involvement in this pilot program will extend the conservation activities that we have already been undertaking, and it will provide us with a network of landholders throughout the Western Division that are undertaking similar activities', Mr Beven said.

Graham and Cathy Finlayson, Bokhara Plains

Graham and Cathy Finlayson of 'Bokhara Plains' near Brewarrina aim to maintain a groundcover level of 40 per cent across their entire property by managing the grazing intensity of domestic stock through rotational cell grazing. Controlling watering points in paddocks that are not being grazed will reduce grazing pressure from feral animals, resulting in a reduction of soil scald areas, improved soil stability and an increase in native perennial grasses.

'Our five year goals for this program are to not only maintain 40% groundcover regardless of the rainfall but to actually improve the type of pasture and increase the biodiversity of our whole ecosystem', Mr Finlayson said. 'By being involved with this program our success will be monitored and documented and will hopefully encourage other landholders to change their approach and be proactive in making the rangelands more ecologically and economically sustainable'.

A SILVICULTURAL SYSTEM FOR SANDALWOOD: A SEMI-PARASITIC SPECIES FOR FARM AND COMMUNITY ENTERPRISES IN SEMI-ARID TO ARID AUSTRALIA

J.E.D. Fox, T.M. Luong, M.C. Cox and T. Carlino

Mulga Research Centre, Department of Environmental Biology,
Curtin University of Technology, GPO Box U1987, Perth WA 6845

ABSTRACT

Declining and irregular supplies of naturally occurring sandalwood have led to increased interest in planting sandalwood either in small lots on farms, or as investment holdings in larger schemes. *Santalum spicatum* (West Australian sandalwood) is an autotrophic, obligatory parasite. Sandalwood seedlings have an early requirement for attachment to hosts that provide nutrition and shade. Survival and growth of sandalwood are related to the success of haustorial connections. It is probable that small holders growing trees for a variety of purposes will have a more suitable base for adding sandalwood than would large enterprises concentrating on single species plantations. Species selected as hosts should be intrinsically useful as well as being able to promote sandalwood growth. In WA, the native, nitrogen fixing species, *Acacia acuminata* has demonstrated the best sandalwood response.

INTRODUCTION

The aromatic heartwood of sandalwood is a valuable internationally traded commodity. It has a wide range of uses such as wood for carvings; wood dust for the manufacture of joss sticks, which are used for religious purposes; and the oil distilled from heartwood that is used in the perfume, medicinal and pharmaceutical industries. *Santalum spicatum* (R.Br.) A.D.C (West Australian sandalwood) occurs in central to southern Western Australia. There is considerable interest in planting WA sandalwood in small lots on farms or as private investment holdings in large schemes. WA sandalwood can be grown in higher rainfall areas on farms to supplement the declining natural stands. The wheatbelt region of WA is ideal as it receives 350-500 mm of rainfall a year (Fox, in press). It is suitable for catchment protection in saline areas, in partially cleared areas, or for enrichment of remnant vegetation. Establishing WA sandalwood on farms has the potential to enhance future value, enable nut crop yields and it adds endemic species to the land (Fox *et al.*, 1996).

WA sandalwood is a slow growing shrub or small tree that can reach 7-8 m in height, but is usually shorter. After 3-4 years of age, it begins to flower and fruit. Mature fruits are 15-20 mm in diameter, with a leathery red-brown exocarp 1 mm thick (Fox, 2000). The kernel is edible and has potential in the speciality nut trade. WA sandalwood is an obligate root hemi-parasite, therefore its distribution is dependent on the presence of potential hosts, with *Acacia* species being the most suitable. Sandalwood can attach to many host roots at the same time and those species growing nearby are most likely to be used as hosts. Sandalwood can produce fragrant heartwood and oil at nine years, when stem diameters can reach 125 mm (at 150 mm aboveground), under summer irrigation.

SILVICULTURE PROTOCOL

Site selection

Sites should be well-drained and water gaining. Waterlogged or heavy clay soils are not suitable. WA sandalwood can be grown in remnant bush areas, reclamation areas, previously cleared land with planted hosts, and along accessways. Sandalwood thrives in loam to sandy loam soils. In the Perth area, it can be grown in sandy soils with irrigation.

Seed collection

Establishment of WA sandalwood is best achieved with directly sown seed. A local seed source is preferred. Mature fruits can be collected around December, when the fleshy mesocarp has dried and is brown in colour. Seeds gradually lose viability, so are best used when one to two years of age. Recently produced seeds do not germinate well until three or four months later.

Establishment

The easiest planting technique is to use open land with regenerating *Acacia* species present. Seeding sites should be prepared in advance; selected areas ripped to a depth of a least 250 mm into contoured furrows (4-5 m or more apart) (Fox *et al.*, 1996). If hosts have been established for less than a year, plant seeds at least 1 m away; if the host is already established, plant seeds 2 m away. This provides shade and shelter for seedlings for the first year or so. Planting two hosts to one sandalwood is recommended. May is the most favourable month to plant host species. It is best to have new hosts established for 1-2 years, before directly sowing sandalwood (Fox, in press).

Multiple host plants for sandalwood have the potential to enhance plantation growth. A host plant should ideally promote sandalwood growth, and also be a useful species in its own right (fuelwood, fodder, timber or fruit). Hosts that extract large amounts of nitrogen from the soil, such as legumes, are generally good hosts for sandalwood in the field (Fox, 2001). *Acacia acuminata* Benth. (jam) and *Acacia aneura* Benth. (mulga) are the most efficient host plants for WA sandalwood. If these species are not available, many other *Acacia* species are satisfactory (Fox, in press). She-oaks (*Allocasuarina* species) may also be good hosts (Fox *et al.*, 1996).

Seed sowing and germination

No pre-sowing treatment is necessary. Direct sowing of individual WA sandalwood nuts next to roots of the host plant is recommended. WA sandalwood is best sown between February to May. Plant single nuts 1 m apart allowing for selective removal of seedlings if necessary to aim for 5 m between plants. If many seeds germinate, the least vigorous can be removed. Sow seeds 15-30 mm below the soil surface. In nature, seedlings begin to emerge 3-6 weeks after the opening winter rains of April or May. Any planting spots without seedlings may be resown the following year.

Maintenance

Young sandalwood seedlings grow better in light shade (about 50%) for the first three years, later thriving in more light. Providing seedlings with slow release fertiliser may be beneficial. Fencing against herbivores, fire control, and weed control are essential, especially when sandalwood is young (Fox *et al.*, 1996). Repeated pruning of sandalwood in its early growth stages to give one stem is likely to improve the value of the tree (Fox, in press). Pruning and trimming of hosts after 4-5 years may be necessary if they are crowding the sandalwood (Fox *et al.*, 1996).

REFERENCES

Fox, J.E.D. (2000). Sandalwood: the royal tree. *Biologist* 47: 31-34.

Fox, J.E.D. (2001). Sandalwood: the prospects and advantages of cultivation of a semi-parasitic species by landowners. *In* 'Forests in a Changing Landscape. Proceedings Commonwealth Forestry Conference'. (Ed Promaco). Promaco Conventions, Canning Bridge, Perth, pp. 537-543.

Fox, J.E.D. (in press). Silviculture of sandalwood: a semi-parasitic species for family farm enterprises in Western Australia. Paper presented at the IUFRO International Symposium in the Black Forest: Contributions of Family Farm Enterprises to Sustainable Rural Development. Gengenbach, Germany, 29 July-1 August 2002.

Fox, J.E.D., Barrett, D.R. and Gentle, R. (1996). Sandalwood for saline sites. *In* 'Proceedings 4th National Conference and Workshop on the Productive Use and Rehabilitation of Saline Lands'. Albany, pp. 335-343.

PROTECTING THE GREAT ARTESIAN BASIN – A SOUTH AUSTRALIAN PERSPECTIVE ON THE MERITS OF A COOPERATIVE APPROACH

D. Leek and K. McShane

Arid Areas Catchment Water Management Board, GPO Box 1671, Adelaide SA 5001

The Great Artesian Basin (GAB) is one of the world's largest artesian water reservoirs, and perhaps arid Australia's most important water resource. GAB springs and soaks provide crucial habitat for rangelands animals, particularly in times of drought, when other water sources are not available.

The discovery of the Basin in the 1880s opened the rangelands of Australia to pastoral and mining development and more recently, to the cultivation of the tourism industry based on the natural beauty of the GAB oases.

Development of pastoralism in this part of Australia was based on sinking progressively more bores, and by 1918 it was estimated that 1500 free flowing bores had been sunk into the GAB, discharging 2,000 megalitres per day. (Habermahl 1980).

The regional impact of this discharge varied considerably, with pressure drops of up to 80 metres in some areas (Habermahl 1980), and the cessation or decline in flow from some bores and natural springs. The unsustainable nature of allowing water to freely flow into a climate with evaporation rates of 3,600 mm per annum, without a full attempt to recoup that water for use became increasingly apparent to all concerned. It is accepted that around 95-98% of water from free flowing artesian wells is lost to either seepage or evaporation. The costs involved with fully capturing all water from a bore for use was however, prohibitively expensive. Furthermore, the technology to cap and pipe artesian wells, with temperatures of up to 100 degrees centigrade and pressure levels of above 1,000 kilograms per area, was not available until the last decade or so. The use of free flowing bores and open bore drains also requires less maintenance and labour time from landholders, and the disincentive to convert to a closed system in terms of time and cost were significant.

South Australian efforts to control the flow of bore water from the GAB date back to 1977 when the State Government, with the support of the Commonwealth, initiated a scheme to rehabilitate GAB bores. Under this scheme State Government personnel were responsible for rehabilitating bores throughout the far north. The success of the program in water savings is unquestionable, with more than 200 wells rehabilitated since the 1970s, resulting in water savings of approximately 105 megalitres per day.

Yet it was not until the introduction of the Great Artesian Basin Sustainability Initiative (GABSI) in 1999 that landholders and local industry were directly involved (in an official capacity) in contributing to the improvement of water use efficiencies from artesian bores. While clearly many landholders had taken steps to improve their water management well before the introduction of the GABSI scheme, the financial and technical support offered through the scheme has greatly contributed to improving access to best practice technology and techniques for rehabilitating artesian bores and the associated distribution systems. It has been this cooperative partnership approach that has provided a catalytic effect for a change in the community's approach to the use of bore water.

The GABSI scheme has operated on a dollar-for-dollar basis, with the Federal Government contributing $31.8 million from 1999 to 2004, and State Governments and landholders matching that amount in money and labour costs. In South Australia, the State Government will contribute $1.76 million over the five-year life of the program, WMC Resources Ltd has contributed $1.2 million and landholders have taken on the responsibility of labour costs and the installation of the extensive pipe networks and associated troughs and tanks.

The scheme has involved converting free flowing bores and open bore drains into capped and piped systems, minimising the impact of evaporation and seepage. Under the scheme, the bore rehabilitation effort has been accelerated, with nearly every pastoral property in the far north area participating in the scheme. Of the more than 300 artesian bores in the far north of South Australia, only around 30 are pending rehabilitation.

With the shared investment in the scheme has come a shared interest in the successful outcome of the program, and the subsequent shift in community attitude towards the efficient use of artesian water is palpable. The community has, in general, embraced the shift to closed bore systems.

The ability to control and spread watering points through the pipe and trough technique has also proved beneficial during the recent drought, with pastoralists able to direct their stock to specific locations on the property in a way which was not possible with open bore drains.

The bore rehabilitation and piping schemes have resulted in better management of the artesian pressures across the basin, improved water management on pastoral leases and greater security of water supply for groundwater dependant wetlands, springs and associated ecosystems.

At the time of writing, it is unknown whether a second round of GABSI funding will be allowed for in the Federal Budget, the results of which will be known by the time of the Rangelands Conference.

Whether the GABSI scheme is continued or not, the last five years have clearly demonstrated the merits of an integrated and cooperative approach to tackling environmental management issues. It has only been through the combined efforts of the landholders, the Commonwealth, State, and WMC Resources that such significant inroads have been made into improving the water efficiency in the far north of South Australia. The GABSI scheme has proven the benefits of involving all stakeholders (and that involvement is more than a token effort) in the process, and through genuine contributions from all participants the full realization of benefits extolled by the various groups have been realized. The key to this success is that stakeholders have been able to see the impacts of the water conservation projects firsthand and relate these outcomes to their own experiences.

The GABSI scheme to date has been a successful venture that should be a candidate for replication in other fields and regions.

In 2003, the South Australian Government prescribed the groundwater of the Far North Prescribed Wells Area, effectively regulating the extraction of water from the South Australian portion of the Great Artesian Basin. The Water Allocation Plan, which will determine what water can be taken from the resource and the conditions under which it can be taken, is currently being developed in consultation with the community. Once the Water Allocation Plan has taken effect, all water users in the region will require a license to extract water from the Basin. It is currently expected that the conditions of these water licenses for pastoral users will require the use of an efficient and closed bore and associated distribution system. The regulatory approach will protect the important water efficiency gains made through the GABSI scheme, and ensure that all landholders work for the protection of the resource. For the vast majority of landholders, who voluntarily participated in the GABSI scheme, such regulations should have little impact on the way in which they manage water. The details of the Water Allocation Plan continue to be developed.

REFERENCES

Habermehl, M.A. (1980). The Great Artesian Basin, Australia. *BMR Journal of Australian Geology & Geophysics* 5: 9-38.

PROFILING OUTBACK LIVELIHOODS: A 'PROOF OF CONCEPT' STUDY

Yiheyis Maru [1], *Tom Measham* [2] *and Roy Murray-Prior* [3]

[1] CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs, NT 0871
[2] CSIRO Sustainable Ecosystems, Regional Futures, Davies Laboratory, Townsville, QLD 4814
[3] Curtin University of Technology, Muresk Agribusiness Institute, Muresk Campus, Locked Bag 1, Northam, WA 6401

INTRODUCTION

The Desert Knowledge and Tropical Savannas Cooperative Research Centres (CRCs) jointly initiated a project provisionally entitled the 'Outback Atlas' project. The Outback Atlas concept had its roots in Tropical Savannas CRC research on ecosystem health (Whitehead *et al.* 2000) and a regional dynamics scoping study conducted by Stafford Smith *et al.* (2003). By definition the Outback Atlas project covered desert and savanna regions. It acknowledged that outback problems were qualitatively different from those identified in densely populated coastal areas. The Atlas was to be dynamic, mapping multiple views, drivers, issues and social-ecological indicators of viability for outback regions. The first of two stages of this project is covered by this poster and is concerned with the 'Proof of Concept' for the Outback Atlas project.

THE PROOF OF CONCEPT STUDY

For the Proof of Concept (PoC) stage of the project, a case study approach was employed to a) articulate the intent, methodology and potential products of the project, b) refine the meaning of the concept of a 'dynamic Outback Atlas' and c) based on a & b, develop a proposal for a full-scale Outback Atlas project. The case studies were Ti Tree (Anmatjere) in the Northern Territory and Greenvale in Queensland.

The case studies involved semi-structured interviews and meetings with community leaders, peak body representatives and general residents who were prepared to take part in the research process. In the Anmatjere case study, participants were from indigenous communities, government service providers, table-grape producers and pastoralists. The Greenvale case study participants were traditional owners, town residents and graziers.

Interviews and workshops with CRC staff and external stakeholders were used to refine the dynamic Outback Atlas concept and to further the development of a full Outback Atlas proposal. The research approach also involved a review of literature.

OUTCOMES

Several of the classic issues affecting outback regions of Australia were demonstrated through the pilot case studies, such as remoteness, high unemployment and limited and unreliable access to basic infrastructure. However, several further issues specific to the regions were also raised. These included seasonal importation of labour by local industries even though there was a high level of unemployment of local people in the Anmatjere region; and access to water supplies for traditional owners in the Greenvale region.

A key area of similarity in both regions was the degree of preparedness of the main community groups to work together to gain mutual benefit. In the Anmatjere region, indigenous people and table-grape producers were working together to improve Aboriginal participation in the industry, and to speed up resolution of native title issues and land release for table-grape production. In Greenvale, town residents were partnering with traditional owners to keep the town 'alive'. However, in Greenvale town residents expressed concern over a lack of collaboration between townspeople and graziers.

There was also weak interaction between indigenous communities and pastoralists in the Anmatjere region.

IMPLICATIONS FOR THE FULL PROJECT

The core issues of both pilot study regions are mainly in the social, economic and cultural domain. Study participants noted the stronger biophysical focus of several research efforts such as the Tropical Savannnas CRC ecosystem health monitoring program (Whitehead *et al.* 2000). It is proposed that the full project employs a series of workshops to develop understanding of the unique issues and drivers of dynamics in the outback regions, specifically including socio-economic and cultural issues. The methodology for the full project will combine wide coverage of outback regions with intensive case studies.

Several other recommendations flow from the PoC stage. Participants noted that views, issues and drivers of viability of the outback regions are not static, which was a connotation of the term 'Atlas'. Consequently, the Outback Atlas has been renamed 'Profiling Outback Livelihoods' to indicate that the project will be dynamic, going beyond a list of issues and a spatial snapshot of the state of resources and services. A mechanism for presenting critical social-ecological changes over time and an exploration of systemic linkages between issues in the socio-economic, cultural and biophysical dimensions were also needed. Where relevant, the project should attempt to assemble information in real-time through negotiated access to websites which update data continuously.

The PoC study articulated four key outputs for the full scale project with a main focus on delivering on the first two:

1. A descriptive conceptual model of stakeholder perspectives, issues and indicators of regional viability and social desirability.
2. Systems representation of the critical features (key issues, drivers and associations) of regional state and dynamics.
3. Integrated sets of existing biophysical, economic and social data at a regional scale, and
4. A synthesis of the three above products into a dynamic 'Outback Atlas'.

The project is expected to facilitate context relevant policy formulation, investment decisions and public discourse on development of the outback regions.

REFERENCES

Stafford Smith, M., Walker, D., Maru, Y., Stoeckl, N., Herr, A., Breen, J. and Greiner, R. (2003). *Options for understanding regional dynamics in northern Australia*, Final Report, Tropical Savannas CRC, Darwin.

Whitehead, P.J., Woinarski, J., Jacklyn, P., Fell, D., and Williams, D. (2000). *Defining and Measuring the Health of Savanna Landscapes: a north Australian perspective.* Cooperative Research Centre for the Sustainable Development of Tropical Savannas, Darwin.

EUROPEAN OLIVE (*OLEA EUROPAEA*) AS AN ECONOMIC AND SUSTAINABLE AGRICULTURAL OPTION FOR THE RANGELANDS

G. Price [1], E.G. Barrett-Lennard [2], J.E.D. Fox [1] and S G. Kailis [3]

[1] School of Environmental Biology, Curtin University of Technology, Bentley, WA.
[2] WA Department of Agriculture, South Perth, WA.
[1] Mulga Research Centre, Curtin University of Technology, Bentley, WA.
[3] Department of Plant Science, University of Western Australia, Crawley, WA.

INTRODUCTION

Decline in global markets for traditional arid-zone products, such as wool, is stimulating the search for new, economically attractive and sustainable agricultural/horticultural options in remote rural areas of Australia (Price *et al.* 2002). On Mount Weld pastoral station, situated in the semi-arid rangeland of Western Australia, trials involving European olive commenced in 1999.

In regions such as central Australia and the Goldfields, there is a history of individual plantings of European olive in semi-arid and arid rangeland environments. However, the absence of commercial quantities of European olive in the interior of Western Australia, where climatic conditions are hot and dry, has been noted (Kailis 1997). Preliminary trials conducted on Mount Weld pastoral station aim to test growth of a semi-commercial quantity of European olive in hot and dry conditions, typical of semi-arid rangelands.

Mount Weld pastoral station is located south of Laverton, which is approximately 350 km north north-east of Kalgoorlie, in central south-east Western Australia. The station covers approximately 800,000 ha and is currently managed by Placerdome Asia Pacific, a company that conducts mining and mineral exploration activities as well as managing the pastoral operations on the station. Trials of potentially commercial crops are part of a biodiversity conservation plan for Mount Weld station (James *et al.* 2001). This plan includes the testing of crops that have potential for sustainable land use in the future, and of enterprises that can play a role in the rehabilitation of degraded land.

MATERIALS AND METHOD

Preliminary trials of European olive were conducted at two sites with contrasting soil types and soil profiles. The first site was established in 1999 at Davis Well where 88 trees from five cultivars were planted on soil with a shallow profile (0.4 - 0.5 m of clay soil above laterite). The second site was established in 2000 at Jubilee Well where 98 trees from 11 cultivars were planted on a soil with a deeper profile (more than 1 m of coarse, sandy soil).

Growth performance assessments were carried out regularly at both trial sites, including the measurement of tree height, crown girth, trunk diameter and an estimation of biomass using the Reference Unit Method (Kirmse and Norton 1985). Direct comparison of the growth performance at these two sites was complicated by the fact that tree placement was randomised at Davis Well but not at Jubilee Well, the two groves were established at different times, and the cultivars selected and numbers of each planted at the sites differed. As a consequence, tree performance was assessed independently at the two trial sites (Price *et al.* 2002).

RESULTS AND CONCLUSIONS

Although the growth performance of European olive at the two sites could not be compared statistically, differences in tree growth were apparent. Differences in biomass were identified (from Reference Unit Method results) between individual groves, as well as individual cultivars, between the period September 2002 to April 2004. Trees from 8 out of 11 cultivars growing at Jubilee Well produced small quantities of fruit during the 2001/02 spring-summer season (cultivars; *Ascolana,* *Kalamata, Jumbo Kalamata, Pendolino, Olea Mission, New Norcia Mission, Verdale* and *Nabtari*). At Davis Well by comparison during the 2001/02 spring-summer season, minimal fruit formation was observed on two trees only (cultivars; *Ascolana* and *Verdale*) (Price *et al.* 2002). Significantly, fruit ripening occurred earlier than at other more temperate olive growing areas in WA.

Importantly, preliminary trials of European olive on Mount Weld pastoral station highlight the fact that this crop may potentially be grown successfully in the semi-arid rangelands. The overall potential of European olive as a commercial crop, however, still needs further evaluation. Results from the first two trials conducted on Mount Weld pastoral station were encouraging, and a third grove was established in 2002 at Hacks Well, which is close to the two original sites and also on Mount Weld pastoral station.

The Hacks Well trial has been designed as a randomised block, to test potential variations in growth performance of European olive subjected to different soil and water conditions. Three different cultivars of European olive have been selected for this third trial, based on results from the preliminary trials at the Davis and Jubilee groves. Further assessment of growth performance and fruit production will be undertaken at the three trial sites on Mount Weld, and this will include detailed recording of fruit production from individual trees and laboratory testing of olive oil quality.

REFERENCES

James, C., True, D., Lamont, R. and Longworth, J. (2001). *A biodiversity conservation plan for Mount Weld station*. Report to Placer Dome Granny Smith.

Kailis, S.G. (1997). Potential for European olive growing in Western Australia. Proceedings of the third international symposium on olive growing. *Acta Horticulturae* 474: 771-775.

Kirmse, R.D. and Norton, B.E. (1985). Comparison of the Reference Unit Method and Dimensional Analysis Methods for two large shrubby species in the Caatinga Woodlands. *Journal of Range Management* 38: 425-428.

Price, G., Barrett-Lennard, E.G., Fox, J.E.D. and Kailis, S.G. (2002). Preliminary report on the growing potential of the European olive (*Olea europaea* L.) under Australian arid-zone conditions. *Advances in Horticultural Science* 16: 131-137.

THE ROLE OF PRIVATE RESERVES WITHIN THE NATIONAL RESERVE SYSTEM

Martin E Westbrooke

Centre for Environmental Management, University of Ballarat, PO Box 663, Ballarat, VIC 3353

BACKGROUND – A COMPREHENSIVE AND ADEQUATE RESERVE SYSTEM

"Central to the conservation of Australia's biodiversity is the establishment of a comprehensive and adequate system of ecologically viable protected areas integrated with the sympathetic management of all other areas." (Commonwealth of Australia 1996). The National Reserve System Program has the primary goal of assisting with the establishment and maintenance of a comprehensive national system of national parks and protected areas for the conservation of Australia's biodiversity. It has been estimated that \$150 million would be required to establish a comprehensive reserve system in Australia (HoRSCERA 1993) however Howard and Young (1995) estimated that \$500 million would be required for NSW alone. In 1997 the Commonwealth Government allocated \$80 million over five years through the National Heritage Trust to develop the National Reserve System and it has been estimated that the states allocate up to \$5 million per annum annually for acquisition. The framework for ensuring adequacy of the reserve system is based on the Interim Biogeographic Regionalisation of Australia. Despite increases over the past ten years there is still inadequate reservation of many ecosystems.

PRIVATE RESERVES

It is frequently argued that we cannot afford extensions to the public reserve system in Australia. However the private sector is increasingly contributing to the reserve system, a process that has been assisted both by changes to pastoral lease conditions and support from the federal government. An advantage for some private nature reserves is that they may not have the commitment to visitation and recreation, thus do not require the management infrastructure that many state government agencies see as essential in most reserves. Binning and Young (1997) recommended that Protected area networks be established including both public and private land managed for conservation, however, government agencies often regard private reserves as supplementary to, rather than part of, the conservation reserve system. Whilst there is widespread support for the concept of private co-operative arrangements for biodiversity conservation there remains concern regarding long-term security and management. Examples of government support for private land conservation include the NHT National Reserves Program and the NSW West 2000 Plus Enterprise Based Conservation Program.

WEST 2000 PLUS ENTERPRISE BASED CONSERVATION PROGRAM

In western NSW the West 2000 Plus Enterprise Based Conservation Program provides funding to manage areas of western lands leases for conservation. This has recognised the benefit of protection of uncleared land rather than costly attempts to rehabilitate previously cleared land. In a pilot program ten projects have been approved leading to the conservation of 65,000 ha of land with significant biodiversity values. The largest of these is on Sturts Meadows Station.

Sturts Meadows

The Sturts Meadows reservation gives protection to 5,500 ha in the Barrier and Bijerkerno Ranges north of Broken Hill. The area includes significant heritage sites and a range of restricted plants and communities including Curly Mallee, *Eucalyptus gillii* open shrubland, a community of very restricted distribution.

NATIONAL HERITAGE TRUST, NATIONAL RESERVE SYSTEM PROGRAM

In 1998/99 the Commonwealth Government invited the community to actively contribute to the enhancement of the NRS under the National Heritage Trust National Reserve System Program (NRSP) and in that period proposals for private land protected areas totalling 113,500 ha were approved (CEM 1999). Much of the support was to non-government organisations such as the Trust for Nature (Victoria) and the Australian Bush Heritage Fund. A condition of such funding is that the property must be formally protected, that an agreed management plan be developed and a Private Protected Area Establishment Agreement is made with the Commonwealth Government (Lee and Szabo 1999). A review of NRSP (CEM 1999) concluded that it had made a significant contribution to the NRS, in particular in focussing land acquisition to IBRA regions of high priority.

Nanya Station, far western NSW

The Centre for Environmental Management at the University of Ballarat has for many years, through the goodwill of pastoralists, used pastoral leases in western New South Wales in its environmental management teaching and research programs. Over the past ten years studies have concentrated on the Scotia Country because of its significance as a reference area due to its relatively short pastoral history. Of particular significance is a system of natural salt lakes of which the most extensive is the Scotia discharge complex situated on Nanya Station. A vegetation survey of the Scotia region (Westbrooke *et al.* 1998) highlighted the significance of the area both in terms of the range of communities in relatively intact condition and the occurrence of species and communities of restricted distribution. The survey revealed the presence of 290 species of which nine had either not previously been recorded or have very restricted distribution in western NSW. Seventeen plant communities occur on Nanya Station of which two, *Halosarcia lylei* low open shrubland and *Hemichroa diandra* low open shrubland do not occur elsewhere in NSW. The University has recently purchased Nanya Station with financial support from the National Heritage Trust. This purchase has the multiple purposes of protecting Nanya's significant vegetation, providing a secure base for teaching and research programs both for the University of Ballarat and other interested groups and demonstrating that conservation reserves can be managed effectively on a low budget when there is no requirement for complex infrastructure.

CONSERVATION AND MINING

In both the Sturts Meadows and Nanya Station examples outlined above, the State Government Agency has recognised the conservation significance of the area but has been constrained by mining issues. In NSW it has been difficult to establish national parks in areas subject to mining leases. Voluntary Conservation agreements do not exclude exploration and mining but are subject to normal planning processes. Where private reserves conserve rare plants or communities the planning process may constrain mining activity.

REFERENCES

Binning, C. and Young, M. (1997). Motivating People - Using Management Agreements to Conserve Remnant Vegetation. Paper 1/97; National Research and Development Program on Rehabilitation, Management and Conservation of Remnant Vegetation. Land and Water Resources Research and Development Corporation.

CEM (1999). Mid-Term Review of the National Heritage Trust: National Reserve Program. Report to Environment Australia. Centre for Environmental Management, University of Ballarat, Mt Helen.

Commonwealth of Australia (1996). National Strategy for the Conservation of Australia's Biodiversity. Canberra.

HoSCERA (1993). Biodiversity. The role of protected areas. House of Representatives Standing Committee on Environment, Recreation and Arts. AGPS, Canberra.

Howard, B. and Young, M. (1995). Selecting and costing a representative expansion of the NSW Protected Area Network. CSIRO Wildlife and Ecology Working Document, Canberra.

Lee, G. and Szabo, S. (1999). The Private Lives of Protected Areas: Private Land in the National Reserve System. Paper prepared for Environment Australia, Biodiversity Group.

Westbrooke, M.E., Miller, J.D. and Kerr, M.K. (1998). Vegetation and flora of the Scotia 1:100 000 map sheet, far western New South Wales. *Cunninghamia,* **5:** 665 –684.

NATURAL RESOURCE MANAGEMENT PLANNING IN THE SOUTH AUSTRALIAN RANGELANDS

I.A. White

SA Rangelands INRM Group, PO Box 78, Port Augusta, SA 5700

Developing an Integrated Natural Resources Management Plan and Investment Strategy (IS) for the South Australian Rangelands region presented some interesting challenges. The general environment during the ten months of 2003/04 taken to develop the Plan and IS, presented some interesting challenges.

The region is large, 538,577 sq km, almost 55% of the state, equivalent to the percentage area of NSW or 7% of Australia. The environment and local conditions at the time were characterised by:

- Ecosystems that are relatively intact from a state perspective. Due to the climate and land capabilities no extensive areas of vegetation have been cleared. This is in stark contrast to the majority of the rest of the state. The 2,250 km dog fence separates sheep country to the south, mainly chenopod shrublands, and cattle country to the north, more varied ephemeral grasslands and Acacia woodlands. While vegetation may be largely intact, the region has exhibited some alarming fauna species extinction rates.
- The greatest ecological diversity in the state - 11 bioregions are represented. The area includes Lake Eyre (the lowest point of the Australian mainland at around 15 m below sea level), mound springs of the Great Artesian Basin, the Flinders Ranges, floodplains of the Channel Country, parts of at least five deserts, significant wetlands such as the Ramsar listed Coongie Lakes etc.
- Harsh climate. Rainfall around Lake Eyre is less than 150 mm per annum while temperatures for Oodnadatta have recently been recognised as the hottest in Australia.
- Vast distances – from north to south the distance is around 850 km, from east to west slightly less at around 800 km.
- Many neighbours – the SA Rangelands has boundaries with four other INRM regions in SA, the Northern Territory, Desert Channels Queensland, and the Western Catchment Management Board and Lower Murray Darling Catchment Management Board in NSW.
- Extreme size of pastoral leases and other management units, for example National Parks. The region includes Anna Creek Station, the largest cattle station in the world at 34,000 sq km, National Parks such as Lake Eyre at 13,500 sq km and Conservation Parks such as Tallaringa (which abuts the SA Rangelands) at 12,700 sq km.
- A sparse population which is declining in numbers. Estimates for the Rangelands INRM region put the population at less than 13,000, which is less than 1% of the state population and equals a density of one person every 41.5 sq km.
- An Indigenous population which constitutes around 18% of the total population for the region, often living on their land, and with particular issues of relevance. These people generally have a very different outlook on NRM that is far more inclusive than more contemporary views.
- A changing economic base. The biggest employer in the region, in terms of both revenue and numbers is the mining/petroleum industry. Tourism, which is growing significantly as people want an "outback" experience, is now worth more to the region than pastoralism. Pastoral enterprises have been present in the rangelands for over 140 years and returns continue to be generally variable and unpredictable depending on seasonal conditions. Employment in the pastoral industry is declining.
- Local government is only present in the townships of Coober Pedy and Roxby Downs. The Outback Areas Community Development Trust, a defacto form of local government present in the rest of the region, supports communities by providing subsidies that contribute to local fundraising efforts to address the communities' priorities.
- Boundaries inconsistent between Government Departments and other interest groups, adding unnecessary complexities to negotiations.

- Pending new legislation. During the planning stage of the SA Rangelands INRM Plan, a new concept for South Australia, a much-anticipated NRM Act, was released for an extensive period of community consultation and finally debated in Parliament. This new Act involved combining three current Acts into one. Given the NRM part of the Act is similar to the INRM title of the Plan, there was enormous confusion in the community as to the purpose for both and what overlaps there were, if any.

CHALLENGES ENCOUNTERED	SOLUTIONS
Developing an NRM Plan and Investment Strategy (IS) in a tight timeframe.	*Utilise existing regional planning documents and incorporate results from previous consultation. (Fortunately relevant plans were readily available and current.)*
Concurrent development of the Plan and IS. Actions in the IS cannot address targets in the Plan when the Plan is not formulated.	*Again, use the existing information and consult widely. Where issues are known the IS can broadly address these and, time permitting, be adjusted to more specifically address targets when developed.*
Ensure the community is adequately consulted.	*Plan the consultation well; fit it around existing events wherever possible; give plenty of notice of planned activities; promote activities widely and often; use local champions to raise interest.*
Ensure the Indigenous community is adequately and appropriately consulted	*As for above, and also get advice on most appropriate methods from local Indigenous people.*
Lack of understanding of the message.	*Ensure that appropriate language is used for the audience and avoid acronyms and jargon. Provide definitions for clarity - use the KISS* principle.*
Community overload. A small population means people are often over-committed to be effectively involved in too many initiatives.	*Keep communications clear, relevant, targeted and efficient and use the best method for the intended outcomes. Encourage the involvement of "new" participants. Provide support where possible.*
Confusion in the community due to apparently similar activities occurring.	*Raise the capacity of the community to be able to differentiate between the concurrent activities by providing clear information that highlights the differences. Use local champions to raise awareness and promote the activity. (During consultation the INRM Group had to provide clear information and be persistent to separate the Plan from the Act and other significant regional issues.)*
Maintaining or developing effective partnerships with neighbouring regions	*Instigate and encourage dialogue with neighbours, especially in relation to mutual issues. Utilise and support existing mechanisms that work effectively across borders. (Through the Lake Eyre Basin process a good relationship already existed with Qld and this was used to mutual benefit in the planning process.)*
Maximise community ownership to ensure strong community adoption	*Keep the community involved at all stages of the process and encourage and use their feedback and suggestions. Emphasise the positive aspects and relevance for the community.*

* KISS – Keep It Simple, Stupid!

PLUMBAGO STATION: AN EXAMPLE OF PASTORAL AND CONSERVATION LANDUSES

D. Wilson

Plumbago Station, via Olary, SA 5440

Plumbago Station is a working example of multiple landuse in the rangelands through the incorporation of conservation goals and activities into the pastoral enterprise, ensuring not only long-term sustainable pastoral production but also the protection and recovery of a threatened species of rock-wallaby.

Located in the North-East chenopod shrublands of South Australia, approximately 150 km west of Broken Hill, Plumbago is a sheep station with an average rainfall of 230 mm and a carrying capacity of approximately 14,000 DSE as set by the Pastoral Board of SA. The 89,000 ha property is located in the Olary Ranges, now home to the largest single population of the Yellow-footed Rock-wallaby (*Petrogale xanthopus*) in South Australia.

Thirteen years ago Plumbago Station was heading in a familiar direction of over-grazing from large numbers of feral animals as well as too many sheep, resulting in severe degradation of native vegetation communities and large weed infestation problems. Rock-wallaby habitat was being destroyed by feral goats, high rabbit numbers were suppressing recruitment of native plant species, and foxes were having a large impact on the native animals as well as the domestic stock. Aerial surveys of the rock-wallabies revealed a risk of local extinction in the long-term if measures weren't taken to secure them, and though not quite as threatened, the pastoral enterprise required similar urgent attention.

With a change of management the focus shifted from being just a sheep station to being a pastoral enterprise that was committed to long-term sustainable landuse with conservation values as a large component of this. The protection of the Yellow-footed Rock-wallaby became a high priority when making management decisions and a list of priorities and strategies on how we could start the recovery program for our property was developed. These included:

- Reduce total grazing pressure.
- With an estimated feral goat population of 10,000, goat control became a very high priority. Mustering and trapping goats started immediately, continuing until numbers were deemed too low to be profitable to muster and a shooting policy was adopted which stands to this day.
- Sheep numbers reduced.
- A total of 5500 sheep were removed immediately.
- Rabbit control.
- Rabbit warren ripping has been conducted around wallaby colonies and continues to be an active part of Plumbago's management. With the introduction of the Rabbit Calicivirus (RHD) in 1995, we've been able to capitalise on low rabbit numbers, which remain very low at present.
- Fox baiting.
- 1080 dried meat baits are laid twice a year for fox control. This started 13 years ago and the results from this are hard to measure other than to see a fox on Plumbago now is very rare but you don't need to travel far where fox baiting does not happen and foxes are quite prolific.
- Weed control.
- African Box Thorns had started to take over a watercourse on Plumbago. With a D6 dozer we took out over 1000 large plants. With two follow-up programs, the box thorns are under control with the watercourse now being very productive for sheep grazing. Other weeds including Pepper trees, Onion Weed and Bathurst Burr have become high priority weeds for Plumbago and new programs to control these are currently being developed.

All of the above require a long-term commitment, which has been Plumbago's philosophy from the beginning. Through implementing our revised management philosophy, a major turnaround has occurred on Plumbago in terms of both the pastoral production business and the viability of the Yellow-footed Rock-wallaby population, as summarised below:

- Yellow-footed Rock Wallaby recovery from a base population of less than 50 in 1991 to now exceeding an estimated 2000 with continuing expansion of animals into long-disused habitat areas.
- Feral goat population from a high of 10,000 + to effectively goat-free. During a local aerial culling operation in April 2004, a total of two goats were found on the property and it is rare that the total number would exceed twenty.
- Fox and cat numbers significantly reduced such that feral predation does not appear to be a limiting factor for rock-wallaby (or lamb) survival.
- Pastoral production increasing with lambing percentages 25 to 30% better than neighbouring properties.
- The ability to maintain stock numbers during drought without feeding supplements and without degrading the resource base.
- Cost of production down due to a lower maintenance requirement on infrastructure previously damaged by feral goats as well as more time to spend on the sheep side of the business and other projects like weed control.
- High recruitment and recovery of native, palatable 'indicator' plants like Bullock Bush as well as Mulga trees, which have in the past failed to recruit or have been heavily grazed.

We believe that we are genuinely operating two distinct yet obviously compatible landuses on Plumbago, rather than just inheriting a species with a conservation requirement that may or may not match our pastoral activities. This is evidenced by our management operations which include active conservation measures designed to protect and recover the rock-wallabies. It should also be noted that the Department for Environment and Heritage (SA) consider our conservation efforts to be not only effective, but essential, and they rely on Plumbago to ensure the species is secure in this area of its former range.

The uptake of multiple landuse in the rangelands is going to become increasingly important in many areas and to many sectors, whether it be production, tourism, conservation or a host of other potential activities. The biggest challenge to us appears to be in convincing other pastoralists that they can have conservation and pastoralism working together and be a viable business.

There is much interest from within the rangeland community on what we are doing and we have received acknowledgement and recognition from government agencies, the Nature Conservation Foundation of SA and through a Banksia Environmental Award in 2003 for Environmental Leadership in the Rural Sector. However, the negativity from within sections of the local community is quite disappointing, despite the obvious benefits that have been proven and documented on Plumbago.

What has been done at Plumbago is viewed by some neighbouring properties as not sustainable, but it is quite the opposite; Plumbago management believes it is the way of the future. Government agencies i.e. the Pastoral Board of SA need to be a lot more proactive rather than reactive. Instead of waiting until there has been everlasting damage done to the rangelands they need to step in and prevent it from happening in the first place. Plumbago needs to continue to put itself out there, to be scrutinised, so that potentially one day in the future some, if not all of its management practices will be adopted when managing the rangelands.

A major challenge for Plumbago management is the ongoing protection of not only the Yellow footed Rock Wallabies but also the overall land systems forever, regardless of management or ownership. It's taken a lot of effort to recover, but it wouldn't take long to undo the gains given a small amount of short-term thinking.

CONSERVATION – ALIGNING THE STARS IN THE WESTERN DIVISION OF NSW

Geoff Wise and Daryl Green

Dept. Infrastructure, Planning & Natural Resources, P.O. Box 1840, Dubbo, NSW 2830

Whilst there has been a growing call for increased conservation of our natural resources, there have been inadequate market signals to encourage voluntary participation by landholders.

A number of instruments are now being aligned in the Western Division of NSW which individually or collectively are changing this, primarily by providing landholders with an economic return for maintaining conservation areas.

A Western Lands Lease rental annual rebate is available for leased land recognised as being maintained for managed rehabilitation. This rebate is 40 cents per hectare for agreements exceeding ten years, or 30 cents per hectare if up to ten years.

Voluntary property vegetation plans, with opportunities for one-off grants from a conservation fund, are a vital plank in the new statewide native vegetation legislation.

Enterprise Based Conservation (EBC) promotes conservation as an alternative to grazing as a legitimate commercial land use, proposing an annual equitable return to the landholder (see paper this Conference).

The WEST 2000 Plus Program has piloted the EBC project, involving over 65,000 hectares on ten properties with annual payments for five years. Outcomes of this pilot program include marketing the concept, gaining an appreciation of the willingness of landholders to be involved, identifying mutually acceptable prices, and determining eligibility criteria, conservation management contracts, mechanism for allocating funds and administrative frameworks.

The Environmental Services Scheme is a statewide pilot project with similar outcomes to the WEST 2000 Plus Program, but it only offers a one-off grant rather than annual payments.

The Southern Mallee Land Use Agreements allow trade-offs of conservation areas for increased areas of clearing and dryland cultivation. Nearly 100,000 hectares of conservation is now permanently secured through perpetual lease agreements.

Privately managed conservation areas, providing an economic return for landholders is now being seen as a viable option for landholders, and as an alternative to state managed national parks in the Western Division.

CONTACT:

Geoff Wise
Regional Director, Far West Region
Department of Infrastructure, Planning and Natural Resources and Western Lands Commissioner
P O Box 1840
Dubbo, NSW 2830
Phone: 02 6883 3040
Fax: 02 6883 3099
E-mail: geoff.wise@dipnr.nsw.gov.au

PAROO RIVER LIFE: A REPORT ON A NARRATIVE APPROACH TO COMMUNITY CONFLICT RESOLUTION

R. Woog and M. Wolnicki

University of Western Sydney – Hawkesbury, PO Box 1797, Penrith South DC, NSW 1797
South West Natural Resource Management Group, PO Box 630, Charleville, Qld 4470

INTRODUCTION

The project was based on an investigation into the use of water within the Paroo River. There was potential conflict regarding water use and the general care and welfare of the river among the people who were currently utilising the river, living in close proximity or in some relation with it as well as among some of the many agencies charged with its control, maintenance and care.

THE PROBLEM AREA

The source of the problem was differing expectations and priorities about water use held by different groups of people living along or in some form connected to the river. Areas of disagreement can be broadly categorised as:

- Upstream demand for water use for crop and pasture irrigation which would benefit substantially many marginal or declining agricultural enterprises.
- Downstream need for adequate floodplain inundation and unpolluted water for livestock production. It was thought that water availability and quality would be compromised by irrigation.
- Throughout the entire length of the river there were those who were concerned about maintaining the environmental, aesthetic and ecological integrity of the river.

ASSUMPTIONS AND THEORETICAL FRAMEWORK

The project was confronted with characteristics that are in common to community disagreements regarding natural or scarce resource use. The risk with such projects is that in moving towards resolution there is a feeling of invalidation by one group or another, a polarisation that is the inevitable outcome of a "yes" or "no" decision. In our inquiry design we sought to go beyond the inherent limitations of such problems. Our hope and expectation was to develop an approach that would transcend the win lose dichotomy.

Complexity theory (Wolfram, 2003; Kauffman, 1995) and Fuzzy logic (Dimitrov, 2002) showed relevance and promise in this regard. Complexity theory explains how multivariate systems show adaptive self organization and through this, exhibit heuristic, and at times symbiotic, outcomes. Fuzzy logic may be thought of as a different way of knowing that does not require strict categorisation or polarities but seeks to explain circumstances where there are degrees of relationships and connectedness. These theories influenced the methodological approach taken.

THE INQUIRY

We collected narratives from groups and individuals throughout the length of the river. This was a form of community consultation which started to pull together the oral history of the river and the region. The narrative flow, combining memories, stories, joys and hardships was like the river itself telling the stories to the listener/recorder as they journeyed down its length. The narratives were written up and made available to the community. We took metaphoric license and titled the narratives "The Voice of the River". It was in this way that we began to introduce new knowledge and alternative points of view to the multiple reviews and discourses that were taking place. It was our expectation and indeed our finding that information provided in this way was more acceptable and less subject to negation than would be more objective and categorised data. To those engaged in the discourse we could point out that they were bringing forth narratives of their own beliefs and values imposing legislation, law prejudices and agendas.

CONCLUSIONS

The project was completed at the end of 2003 but discourse about and planning for the river is continuing. Our contribution is seen not as resolving the conflict but in having raised the standard of the conflict resolution process. Through the device of "The Voice of the River" we have sought to produce and contribute to the discourse a common sense aesthetic interpretation which would inform, stir emotions but above all would seek to heal.

The significance of this research is in the finding that if a community can be made aware of the range of values, hopes and expectations which exist within it and incorporate and address these in conflict resolution, they are likely to reach more sustainable and just outcomes.

In complexity terms we would describe our contribution as:

- Having informed and energised the discourse by ensuring it contained the requisite variety.
- Having sensitised participants to be aware of, and to look for, emergent outcomes; not just to move towards pre-planned categoric goals.

REFERENCES

Dimitrov, V. and Hodge, B. (2002). *Social Fuzziology, Study of Fuzziness of Social Complexity.* Phisica-Verlag, Heidellberg, New York.

Kauffman, S. (1995). *At Home in the Universe.* Oxford University Press, Oxford.

Wolfram, S. (2002). *A New Kind of Science.* Champagne. Wolfram Media, Illinois.

Monitoring

(Poster Group Seven)

STOCKTAKE – A PADDOCK-SCALE, GRAZING LAND MONITORING AND MANAGEMENT PACKAGE

J.L. Aisthorpe [1], *C.J. Paton* [2] *and P.K. Timmers* [3]

[1] DPI&F, LMB 6, Emerald Qld 4720; [2] DPI&F, PO Box 118, Gayndah Qld 4625;
[3] NRM&E, 80 Meier's Road, Indooroopilly Qld 4068

INTRODUCTION

Traditional natural resource monitoring systems have failed to establish clear links between field measurements and on-ground management actions required to maintain the resource. *Stocktake* is a paddock-scale land condition monitoring and management package that has been developed to provide grazing land managers with a practical, systematic way to assess land condition and long-term carrying capacity, and to calculate seasonal paddock forage budgets.

Using indicators of paddock condition, together with grass growth predictions for local land types by GRASP (Littleboy and McKeon 1997), Stocktake allows managers to quantify the effect that sub-optimal land condition is having on their long-term paddock carrying capacity. The forage budgeting technique has been included as a second component of the system. It provides a dynamic tool for land managers to adjust stock numbers based on seasonal forage supply.

A FRESH APPROACH

Prior to the development of this package, the most commonly recognised grazier pasture monitoring system in Queensland was GRASS Check (Forge 1996). Land managers using GRASS Check developed a high level awareness and knowledge of the pasture species present in their paddocks. However, few were able to apply such raw data in their strategic or tactical decision making.

A review of resource monitoring by Brown *et al* (1996) stated that, at the enterprise level, monitoring should be done for the purpose of improving short- and long-term productivity via a process of adaptive management. Thus, such systems should not only alert graziers about changes in the composition or condition of particular resources, but also be able to extrapolate that into a business productivity context. For this to happen, three key areas needed to be addressed: (a) scale of assessment; (b) resource monitoring in terms of ecosystem health and long-term productivity; and (c) data management and meaningful interpretation of results. Each of these components was addressed in Stocktake.

Scale of assessment

Grazing land managers are required to make stocking and management decisions on a paddock-by-paddock basis. Many existing resource monitoring systems are point, or transect based, and focus on collecting data about specific aspects of the grazing system. In extensive grazing systems, where paddocks often have a heterogeneous mix of landforms, soils, vegetation and infrastructure, a point-scale monitoring system alone is inadequate for broad scale assessment of land condition. Stocktake allows monitoring and assessment of a paddock at a land type scale.

Resource monitoring in terms of ecosystem health and long-term productivity

The ABCD land condition-scoring framework, introduced in the Grazing Land Management Workshop (Chilcott *et al.* 2003), provides a standard means of assessing and rating grazing land condition. This framework scores land condition based on an assessment of key indicators of current soil, pasture and woodland condition. "A" land condition is when the ecosystem is in the best condition and ecosystem processes, including cycling of nutrients, cycling of water and energy flow, are most efficient. "D" land condition is when it is poorest and requires remediation.

By using an ecosystem approach, the system acknowledges the importance that all components have on grazing productivity, for example, poor soil surface condition or woodland thickening. In a pasture-only monitoring system such imbalances would go unnoticed. A simple field assessment system for the ABCD scoring framework has been developed for Stocktake. Outputs allow an assessment of the potential for productivity and resource improvement. Forage budgets provide a means for then tactically adjusting stock numbers based on seasonal conditions.

Data management and meaningful interpretation of the results

A key downfall with many monitoring 'systems' has been the lack of meaningful interpretation and reflection about the results by grazing land managers. McGill (1995) highlighted that thinking through reflection is the essential link between past action and more effective future action.

The Stocktake package includes a comprehensive database which chronologically stores, collates, reports on and interprets the field data in terms of short and long-term carrying capacity. Information that can be generated by the database includes:

- Land condition of land types within a paddock ("A" to "D"),
- Paddock carrying capacity in current ("A" to "D") and in optimum ("A") land condition,
- Number of days the current forage in your paddock will last with current stock numbers, and
- Number of adult equivalents that can be carried in a paddock for a particular period whilst maintaining a desired dry matter residual.

CONCLUSIONS

The Stocktake package takes grazing land monitoring to a new level by not only collating data about key paddock resource indicators, but also managing and interpreting the information in a way that most grazing land managers can relate to and use in their business planning. By practically reinforcing key technical concepts from Grazing Land Management Workshops, Stocktake provides a catalyst for bridging the gap between paddock resource assessments and grazing land and stock management decision-making.

REFERENCES

Brown, J. *et al.* (1996). Monitoring for resource management *In* 'Monitoring Grazing Lands in Northern Australia' (Eds J. Tothill and I. Partridge). Tropical Grasslands Society of Australia Occasional Publication 9: 57-66.

Chilcott, C.R. *et al.* (2003). Grazing Land Management Workshop Notes – Burnett. Meat and Livestock Australia Limited, Sydney.

Forge, K. (1996). GRASS Check – Grazier Rangeland Assessment for Self-Sustainability. Information Series Q194005. Queensland Department of Primary Industries, Brisbane.

McGill, I. and Beaty, E. (1995). What is Action Learning and How does it Work? *Action Learning – A Practitioner's Guide*, 2nd Ed. Kogan Page, London, pp21-39.

Littleboy, M. and McKeon, G. (1997). Subroutine GRASP: Grass production model. Appendix 2 of 'Evaluating the risks of pasture and land degradation in native pasture in Queensland'. Final Project Report for RIRDC project DAQ124A. Queensland Department of Natural Resources, Brisbane.

INDICES FOR ASSESSING LANDSCAPE LEAKINESS AT MULTIPLE SCALES

Gary Bastin [1], *John Ludwig* [2], *Robert Eager* [3], *Adam Liedloff* [3] *and Vanessa Chewings* [1]

[1] CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs NT 0871
[2] Tropical Savannas CRC & CSIRO Sustainable Ecosystems, PO Box 780, Atherton Qld 4883
[3] Tropical Savannas CRC & CSIRO Sustainable Ecosystems, PMB 44, Winnellie NT 0872

INTRODUCTION

It is generally accepted that healthy rangeland landscapes are those that function to conserve resources by retaining water, soil and nutrients. How well landscapes retain, not 'leak', water and soils is largely determined by the cover and spatial arrangement of perennial (more permanent) patches of vegetation. We have developed a leakiness index based on very high resolution remote sensing that indicates degree of resource retention on hillslopes (Ludwig *et al.*, 2002) and thereby provides an index of landscape function. This index should allow up-scaling of ground-based landscape function assessment that is now an established procedure in some agency monitoring programs. However, there is a need to continue this up-scaling process so that indicators of potential leakiness are available for application at larger landscape scales. In this poster paper we briefly review features of current leakiness indices and point to planned further developments.

DIRECTIONAL LEAKINESS INDEX (DLI)

This index is applied at hillslope scale by sampling areas up to several hectares. Images of very high pixel resolution (e.g. 0.2 – 2.5 m pixel size) are used. Smaller pixel sizes (and image size) are typically available with aerial videography. Satellites such as Quickbird and Ikonos now supply multispectral imagery of ~2.5 m pixel size for areas of >100 sq km. Pixels need to be classified into either patch or fetch: patches are resource-conserving clumps of perennial vegetation (typically trees, shrubs and tussock grasses) while fetches comprise bare ground, and areas covered by litter and annuals. DLI assumes directional flows down the hillslope and the image area of interest is rotated so that flow is down columns of pixels. On relatively flat areas where flow direction may be uncertain, we calculate leakiness down columns and across rows, then average the two values to obtain a multi-directional leakiness index. DLI is scale dependent and scaling criteria are applied to standardise index values obtained from hillslopes of different size.

The index has been published; index formulation and a demonstration of its application are available in Ludwig *et al.* (2002). DLI has been compared against other potential indicators of landscape leakiness and produced similar results to the lacunarity index (Bastin *et al.*, 2002). While lacunarity is based on the size of gaps (= fetches) in the image, it does not appear to account for the locations of gaps as well as does DLI. Testing showed that DLI better indicated leakiness in images, compared with lacunarity, as patch cover decreased. The DLI program is available from Adam Liedloff (in Visual Basic) or Vanessa Chewings (Fortran version).

COVER-BASED DLI (CDLI)

This index overcomes the limitations of the binary patch-fetch classification of DLI, particularly when working with the larger pixel sizes that are commonly available from satellite imagery. It uses continuous cover within pixels. Cover is estimated with an appropriate vegetation index such as the PD54 index for the predominantly red soils of central Australia (Pickup *et al.*, 1993). This index:

- Is recommended for hillslopes (or portions thereof) up to about 1200 m in length. The method is scale dependent so we recommend image sample-size criteria for its use.
- Is suitable for the larger pixels of high resolution satellite imagery (e.g. 15 m Landsat TM panchromatic, 30 m Landsat TM multispectral, 10 m SPOT XS, 20 m SPOT MSS). A cautionary note here is that the higher resolution panchromatic band may not reliably indicate cover.

- Calculates a progressive leakiness value down the hillslope based on the assumption that areas (pixels) with higher cover tend to retain more resources while pixels with lower cover leak resources.
- Requires that the image area (hillslope) is rotated so that resource flows are down columns. We suggest that features such as hills and the drainage network should provide suitable context to determine the required image rotation.

A paper describing the method and its application is currently under peer review before being submitted to a journal (probably *Ecological Indicators*).

LEAKINESS & HIGH RESOLUTION DIGITAL ELEVATION MODEL

A leakiness index that includes information about flow direction from a DEM is currently under development. We envisage that the index will be a refinement of CDLI that estimates the potential leakiness of each pixel with progressive leakiness accumulating in the DEM flow direction rather than directly down columns. Likely features include:

- The ability to rapidly estimate potential leakiness where a high resolution DEM exists. There are few examples of this to date in the rangelands but this is changing with new sources of remotely sensed data (e.g. ASTER satellite imagery).
- Increased index precision compared with DLI and CDLI through the ability to consider non-linear flow directions.
- Wider application including more complex landscapes such as several hillslopes within a sub-catchment.

This index is intended as an improved indicator of the potential leakiness of landscapes where suitably precise DEMs are available, rather than an attempt to calculate actual losses of water and sediment from catchments.

LEAKINESS & COARSER RESOLUTION DEM

Our final development of an up-scaled landscape leakiness index is conceptual at this stage. We see potential benefit in combining multitemporal satellite imagery with the GEODATA 9-second DEM (see http://www.ga.gov.au/nmd/products/digidat/dem_9s.htm). This could provide a rapid way of estimating temporal trends in relative leakiness per pixel for large areas. Multitemporal estimates of vegetation cover could come from MODIS imagery (250+ m pixels) or from finer resolution Landsat imagery where suitable databases exist (e.g. the Australian Greenhouse Office database (Richards and Furby, 2002) that provides continental coverage at 25 and 50 m pixel resolution). The coarse resolution DEM when combined with MODIS imagery may dictate that we look at the relative leakiness of pixels, and change in their leakiness values over time, rather than potential resource transfers amongst pixels. However appropriate statistical summaries may make it possible to compare the leakiness of similar landscape types (e.g. paddocks) with different grazing management histories. Stay tuned for further developments.

REFERENCES

Bastin, G.N., Ludwig, J.A., Eager, R.W., Chewings, V.H. and Liedloff, A.C. (2002a). Indicators of landscape function: comparing patchiness metrics using remotely-sensed data from rangelands. *Ecological Indicators* **1,** 247-260.

Ludwig, J.A., Eager, R.W., Bastin, G.N., Chewings, V.H. and Liedloff, A.C. (2002). A leakiness index for assessing landscape function using remote-sensing. *Landscape Ecology* **17,** 157-171.

Pickup, G., Chewings, V.H. and Nelson, D.J. (1993). Estimating changes in vegetation cover over time in arid areas from remotely sensed data. *Remote Sensing of Environment* **43,** 243-263.

Richards, G. and Furby, S.L. (2002). Sub-hectare land cover monitoring: Developing a national scale time-series program. *Proceedings 11th Australasian Remote Sensing and Photogrammetry Conference.* Brisbane, Australia, on CD-ROM. 9 pp.

ACRIS – TRACKING CHANGE IN AUSTRALIA'S RANGELANDS

Gary Bastin and the ACRIS Management Committee

ACRIS Coordinator, CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs NT 0871

INTRODUCTION

ACRIS is the Australian Collaborative Rangeland Information System. It is a coordinating mechanism that brings together rangeland information from State, Northern Territory and Commonwealth agencies and other sources. Funding is provided by the Australian Government through the Natural Heritage Trust (NHT2) as well as contributions from the participating agencies in the States and NT.

ACRIS grew out of the Rangeland Monitoring theme of the first phase of the National Land and Water Resources Audit and its detailed report *Rangelands – Tracking Change* (NLWRA 2001, http://audit.ea.gov.au/ANRA/atlas_home.cfm). It has a Management Committee comprising representatives of Australian and State/NT Governments (membership listed at the end of this poster paper) and a small Management Unit co-located with the Desert Knowledge CRC in Alice Springs.

OBJECTIVES

It is intended that ACRIS:

- Deliver improved understanding of monitoring outcomes of management strategies and policy at the regional to state and national scale.
- Facilitate cross-jurisdictional and national reporting based on integrating and aligning the separate monitoring activities of States, the NT and Commonwealth.
- Assist NRM managers at regional scale to assess the outcomes of their activities.
- Allow improved scrutiny of returns on government investment within regions e.g. by predicting the impact of new developments and policy initiatives.
- Support improved priority setting for government, community and industry investment.

The Management Committee has an agreed workplan and terms of reference. ACRIS reports to the ministerially appointed NRM Programs and Policy Committee (formerly the Land, Water and Biodiversity Committee) on the development of a policy framework for reporting. It reports to the NLWRA Advisory Council on progress and issues with implementation.

ACRIS ACTIVITY

Each State and the NT has established procedures for monitoring, particularly of the pastoral estate, but the different attributes assessed, methods of data collection and densities of data will likely provide early challenges in reporting in a consistent and coherent manner across jurisdictional boundaries. The Management Committee has set itself and the Management Unit the initial task of reporting on management-oriented issues using existing data for a specified region in each State / NT. This will test our ability to report (addressing a set of nationally relevant focus questions) using readily available monitoring data. From there, the task will be expanded to more comprehensive reporting on the condition of natural resources across the entire rangeland area of each jurisdiction using existing data. These expanded reporting criteria could include:

- surface and groundwater,
- vegetation change on pastoral land,
- seasonal climate outlooks and satellite-derived change in seasonal characteristics (as contextual information),
- change in land use and tenure, and

- extent of tree clearing.

ACRIS will progressively implement more comprehensive reporting of change in Australia's rangelands. For example, a recent national workshop addressed methods for monitoring change in biodiversity (Smyth *et al.* 2003) and we now need to consider how suitable methods can be included in expanded monitoring programs. Other work will examine how best to monitor change in the social and economic wellbeing of regions. The ultimate challenge for ACRIS is to develop the full suite of products described in *Rangelands – Tracking Change* that will allow comprehensive and timely reporting on the condition of natural resources in the rangelands. The expanded reporting criteria could include:

- biodiversity monitoring and analysis,
- trends in socio-economic status,
- landscape assessment at larger scale,
- extent, timing and frequency of fire,
- resource condition,
- locations and status of exotic plants and animals, and
- periodic assessment of total grazing pressure.

Watch the rangeland literature (and National Land and Water Resources web site) for some ACRIS outputs.

MEMBERSHIP OF THE MANAGEMENT COMMITTEE

Annemarie Watt & Deborah Foulcher (secretariat), Dept. Environment & Heritage, Australian Government
Jim Donaldson / Warwick Jones, Dept. Agriculture, Fisheries & Forestry, Australian Government
Blair Wood, National Land & Water Resources Audit
Margaret Friedel, CSIRO Sustainable Ecosystems
Mark Stafford Smith, Desert Knowledge CRC
Ian Watson, Dept. of Agriculture, WA Government
Angas Hopkins, Dept. Conservation & Land Management, WA Government
Bob Karfs, Dept. Infrastructure, Planning & Environment, NT Government
Eric Anderson / Mick Quirk, Dept. Primary Industries, Qld Government
Peter Young, Environmental Protection Agency, Qld Government
Daryl Green, Dept. Infrastructure, Planning & Natural Resources, NSW Government
John Chappel & Brendan Lay, Dept. Water, Land & Biodiversity Conservation, SA Government

REFERENCES

NLWRA (2001). *Rangelands – Tracking Changes. Australian Collaborative Rangeland Information System.* National Land and Water Resources Audit, Commonwealth of Australia. 175 p.

Smyth, A., James, C. and Whiteman, G. (2003). *Biodiversity Monitoring in the Rangelands: A way forward.* Report to Environment Australia, vol. 1, Centre for Arid Zone Research, CSIRO Sustainable Ecosystems, Alice Springs. 50 p.

LONG-TERM ASSESSMENT OF TROPICAL ARID GRASSLAND IN THE FORTESCUE VALLEY FLOODPLAIN, PILBARA, WESTERN AUSTRALIA

T. Carlino, J.E.D. Fox, M.C. Cox and T.M. Luong

Dept. Environmental Biology, Curtin University of Technology, GPO Box U1987, Perth WA 6845

ABSTRACT

Perennial and annual grass densities and cover (more so) have fluctuated with rainfall since 1993 but have generally increased. Low mean density and cover values have eventuated in years with low summer rainfall. Flooding also plays a role in determining pasture condition. Some perennial grass species have the ability to form butts and appear to be capable of regrowth from apparently moribund butts after flooding. Areas that have experienced flooded conditions have shown increases in perennial and annual grass density and cover. This study has demonstrated that grass cover is mainly determined by rainfall.

INTRODUCTION

Generally, prolonged periods of low rainfall and localised overgrazing can result in a decline in annual and perennial species on floodplains. Many perennial and annual grass species are thought to be reliant on certain levels of minimum rainfall and (or) flooding for germination, establishment and growth. The Pilbara climate is arid, with high summer temperatures and low mean annual rainfall. Long-term means (1981-2003) for summer (Dec-Apr) and annual rainfalls are 246.3 and 313.2 mm for Ethel Creek station and 333.3 and 389.9 mm for Marillana station. A study was conducted by the Mulga Research Centre (1993-2003) to assess seasonal vegetation changes downstream of the Ophthalmia Dam along the Fortescue River floodplain on Ethel Creek, Roy Hill and Marillana stations.

MATERIALS AND METHODS

Sixty permanent plots were established, covering the floodplain of the upper Fortescue River north of Newman in the Pilbara and adjacent areas as controls. Land use is cattle ranching, most plots are on Ethel Creek, Marillana (100 km north-west of Ethel Creek) and Roy Hill (north of, and adjacent to, Ethel Creek) stations. Data from four representative regions of the 11 sampled in the area have been used in this paper. These are Jackson's Bore (8 plots); Grasslands (7 plots, 2 plots from 1996); Roy Hill Junction (4 plots), and Marillana (6 plots). Ground cover vegetation assessment involved recording the density (number of live individuals rooted within the quadrat) and percentage cover (the sum of projective foliage) of all species within continuous 1 sq m quadrats along two 25 m transects at each plot. For Ethel Creek and Roy Hill plots, long-term summer rainfall means were calculated using Ethel Creek rainfall data; the means for Marillana plots were calculated using Marillana rainfall data.

RESULTS

Over the period 1993-2003, summer rainfall was lowest in 1993, 1994 and 1998, and was slightly higher than the long-term summer mean (1981-2003) between 1995 and 1997; summer rainfall in 1998 was very low (<70 mm). During 1999 and 2000, summer rainfall levels were the highest in more than 50 years at Ethel Creek (648.5 and 670.2 mm respectively) and Marillana (747.7 and 790.8 mm respectively). Since 2001, summer rainfall has continued to be above the long-term summer mean, although substantially less than that recorded in the previous two years.

Perennial grass densities and cover have varied among regions. Substantial declines in density and cover values were observed in the lower rainfall years, especially in 1998. Increased summer rainfall in 1999 produced substantial increases in perennial grass cover at all regions in that year. In 2000, cover increased at Jackson's Bore and Roy Hill Junction but decreased at Grasslands and Marillana. Mean perennial grass cover was lower in 2001-2003. Mean perennial grass density peaked in 2003 at

Grasslands and Jackson's Bore despite lower mean summer rainfall than in 1999-2002. Density values were lower at Marillana and Roy Hill in 2003. Dominant perennial grass species observed were *Eriochloa pseudoacrotricha* (Jackson's Bore), *Leptochloa digitata* (Jackson's Bore), *Eriachne benthamii* (Grasslands), *E. flaccida* (Grasslands), *Astrebla pectinata* (Grasslands), *Eulalia aurea* (Marillana) and *Panicum decompositum* (Jackson's Bore).

Annual grass density and cover were better correlated with rainfall than perennial grasses. Mean density remained low in the low summer rainfall years 1993-1994, 1996 and 1998, and higher densities were noticeable in 1995 and 1997 after slightly higher rainfall. In 1999, annual grass cover increased substantially at all regions and remained high in 2000 following continued high summer rainfall. Mean cover declined in 2001, coinciding with lower rainfall, and remained low to 2003. Dominant annual grass species observed at various regions were *Dichanthium sericeum* (Jackson's Bore; Roy Hill Junction), *Eragrostis tenellula* (Jackson's Bore; Roy Hill Junction; Marillana), *Panicum laevinode* (Jackson's Bore), *Iseilema membranaceum* (Jackson's Bore) and *Chloris pectinata* (Roy Hill Junction).

DISCUSSION

Perennial and annual densities have fluctuated with rainfall but values have generally increased since 1993. Low mean density and cover values prevailed prior to 1999, especially in years experiencing below mean summer rainfall. Australian native grasses generally require a high water potential in order for germination to occur (Maze *et al.*, 1993). Very high summer rainfall levels in 1999-2000 increased density, and cover more so, compared with other years. Since 2001, summer rainfall has continued to exceed the long-term summer mean, although at substantially lower values to those experienced in 1999-2000. Grasses generally respond rapidly to favourable rain and deep-rooted tussock grasses can retain green foliage for up to ten weeks (Hunter and Melville, 1994). Annual grasses demonstrate seasonal sequences and are more opportunistic, while perennial grasses can persist through the year as green plants pending moisture availability (Xin *et al.*, 1996).

Rainfall *per se* is not the only factor involved in the variation in grass density, cover and health. Rainfall intensity and resultant flooding also affect grass growth, survival and renewal. Observations following prolonged flooding in 1995 suggest that flooding can result in negative effects on the health of longer-lived perennial grass species. However, flooding can be beneficial. In 1995 and 1997, several areas experienced short-term flooding following rainfall above the long-term summer mean. As a result, density and cover increased slightly at most regions. Some species of perennial grass (e.g. *Chrysopogon fallax, Eriachne benthamii* and *Panicum decompositum*) form butts in low rainfall years and appear to be capable of regrowth from apparently moribund butts in favourable conditions (such as after flooding). Areas on Ethel Creek, Roy Hill and Marillana have been overgrazed (high stocking rates) in the past (Payne and Mitchell, 1992). Effects have been compounded with low rainfall years and lack of flooding. More recently, lower stocking rates and higher rainfall have coincided with improved pasture growth. The study has demonstrated that grass cover is determined by seasonal rainfall patterns.

REFERENCES

Hunter, D.M. and Melville, M.D. (1994). The rapid and long-lasting growth of grasses following small falls of rain on stony downs in the arid interior of Australia. *Australian Journal of Ecology* 19: 46-51.

Maze, K.M., Koen, T.B. and Watt, L.A. (1993). Factors influencing the germination of six perennial grasses of central New South Wales. *Australian Journal of Botany* 14: 79-90.

Payne, A.L. and Mitchell, A.A. (1992). An assessment of the impact of the Ophthalmia Dam on the floodplain on the Fortescue River on Ethel Creek and Roy Hill. Western Australian Department of Agriculture. *Technical Report* 124.

Xin, H.Z., Jeanes, B.H. and Fox, J.E.D. (1996). Assessing status and trends in the tropical arid grassy pastures. *In* 'Conference Papers. 9th Biennial Australian Rangelands Conference.' (Eds L. P Hunt and R. Sinclair). Port Augusta, South Australia. Australian Rangelands Society, pp 157-158.

MEASURED CHANGE IN THE RANGELANDS OF WESTERN NSW: 1989-2003

R. Grant [1], *D. Eldridge* [2] *and G. Horn* [3]

NSW DIPNR, [1] PO Box 77, Condobolin, NSW 2877, [2] C/- University of NSW, Sydney, NSW 2052, [3] PO Box 1840, Dubbo, NSW 2830

INTRODUCTION

The Rangeland Assessment Program (RAP) is an operational site-based monitoring system measuring vegetation change in western New South Wales (Green *et al.* 2001). The initial design of the program focused on identifying trends in land condition to stimulate landholder interest and provide objective data at the state policy level. Increasingly there is a demand for data to support the monitoring of "catchment level" natural resource management outcomes and to ground-truth regional modelling.

For the past 14 years, annual assessments have been undertaken at up to 340 monitoring sites throughout the western rangelands of NSW. The temporal scale of this monitoring is the most intense in Australia. The program therefore possesses a comprehensive dataset on plant and soil surface responses to seasonal effects and pastoral management. Selected statistical analysis of the data has been completed (Eldridge and Coen 2003), but this paper reports on general trends evident at broad spatial scales.

REGIONAL TRENDS

Fourteen years is a short timeframe for recognising real change in rangeland pastures. Regional trends in the data therefore highlight the well-known seasonality of pasture response in the semi-arid zone. While exceptionally dry or wet years define a broad context for pasture growth, individual species respond to more specific events. However, beyond seasonal impacts, plant diversity, frequency, biomass, soil surface cover and chenopod density datasets provide robust evidence of long-term site dynamics. In the following, these are considered in the context of the whole of western NSW.

Pasture diversity

Pasture diversity, measured by the average number of individual plant species recorded at each site, appears to be relatively stable across the region. Different responses are evident between specific range-types or biogeographic regions. High variability and peaks of diversity are evident in the Cobar Peneplain and Mulga Lands Bioregions. In comparison, the belah (*Casuarina pauper*)-rosewood (*Alectryon oleifolius*) communities of the Murray-Darling Depression Bioregion exhibit low but more consistent diversity. As would be expected, diversity has been greatest following years of exceptional rainfall. We suspect that this is especially so when they follow dry seasons. Across the region, about 80% of pasture species are of native origin. The "non-natives" include weeds as well as pastorally productive plants such as barley grass (*Hordeum leporinum*) and medics (*Medicago spp*).

Pasture composition

Regional trends in individual pasture species frequency and biomass closely follow seasonal rainfall totals and the timing of the growing season. Speargrass *(Austrostipa spp)*, the dominant grass in the region, grows best on autumn or winter rainfalls and produced big flushes in 1989-90, 1992-93 and 2000-01. Many perennial grass species such as curly windmill grass (*Enteropogon acicularis*) maintain a relatively low presence in pastures at any one time. However, collectively their productivity remains relatively consistent year to year in contrast to the "boom or bust" cycles of many annual plants and speargrass. Number nine wiregrass *(Aristida jerichoensis*), which tends to be summer growing, did best in 1995 when rains were predominantly in January, as well as in 2000-01. Curly Mitchell grass (*Astrebla lappacea*) showed increasing biomass throughout the 1990s, although declining in 1998 with mainly winter rainfall.

In southern parts of the western NSW rangelands, medics and crowfoot (*Erodium spp*) are generally considered the most important non-grass pastoral plants. However, the data confirm that their growth is quite seasonal, resulting in significant variation in the yields recorded at monitoring sites. This was evident in the years 1993-97, when the palatable native, grey copperburr (*Sclerolaena diacantha*) produced greater biomass.

Soil surface cover

The amount of vegetation cover and cryptogam on the soil surface is a good indicator of seasonal response, grazing pressure and consequent land stability. As sites are measured during autumn in predominantly winter rainfall areas and in spring where summer rain dominates, the data represent the "worst case scenario" in terms of groundcover. Over the last decade, cryptogam cover has been relatively stable. However, vegetation cover has responded to the better rainfall years but declined slightly overall. There appears to be a slight trend towards more bare ground over the period, whilst erosion levels show a slight downward trend.

Chenopod density

Edible chenopod shrubs play a big part in maintaining soil stability and pastoral productivity over a significant area of western NSW. Bladder saltbush (*Atriplex vesicaria*) is the most important of these shrubs. During the early part of the last decade, this saltbush was badly affected by caterpillar attack, dieback and drought. Fortunately, bush density made a good recovery with better rainfall during 1999-2000, but then rapidly declined again with the onset of the current drought. Other chenopod species, such as old man saltbush *(Atriplex nummularia)* and pearl bluebush *(Maireana sedifolia)*, have demonstrated relatively stable numbers over the period. Black bluebush *(Maireana pyramidata)* showed substantial recruitment of younger plants after 1996, only to be thinned by the drought since 2001. The recruitment coincided with the introduction of rabbit calicivirus.

ARE THE NSW RANGELANDS CHANGING?

Over the 14-year timeframe of monitoring, significant ecological change is not readily evident in the broad regional context of the western rangelands of NSW. At this scale, annual change is mainly driven by season and the actual circumstances of each growing period have more influence than annual rainfall totals. Seasonal variation tends to disguise real ecological trends due to land use or other factors. As many ecological changes in semi-arid rangelands occur very slowly, even 12-14 years of annual monitoring provides a limited view of long term trends.

Rangelands are complex. The changes described here simplify dominant trends averaged across many different sites. Each site has specific circumstances. However, site-specific data demonstrate our ability to report on issues such as saltbush dieback and responses to rabbit ripping (Green *et al.* 2001).

Site-based monitoring has both advantages and limitations in defining change in the spatial context of rangelands. We consider that RAP ground-based data used in conjunction with emerging remote sensing technologies will provide the most objective reporting on the health of the rangelands of western New South Wales. Proposed extensions to the RAP program therefore include case study investigations of remote sensing for spatial extrapolation of the point samples to broader areas of western NSW. Remotely sensed images are available for a similar time period as that of the RAP data, allowing direct comparison between the two datasets.

REFERENCES

Eldridge, D.J. and Coen T.B. (2003). Detecting environmental change in eastern Australia: rangeland health in the semi-arid woodlands. *Science of the Total Environment* 310, 211-219.

Green D., Richards, R., Hart D. and Watson, I. (2001). Rangeland monitoring, condition assessment and resource inventory activities in New South Wales conducted by the Department of Land and Water Conservation. Report prepared for the National Land and Water Resources Audit, Canberra.

EVALUATION OF A MODELLING APPROACH TO ESTIMATE DYNAMIC SOIL COVER

Stephan Heidenreich and John Leys

NSW Department of Infrastructure, Planning and Natural Resources, Gunnedah NSW 2380

INTRODUCTION

Soil cover levels have been listed in the Catchment Management targets of the NSW Catchment Management Authorities (CMAs) because of the strong link between soil cover and erosion. Total soil cover can be divided in to the dynamic (herbaceous) and non-dynamic (rock, litter and cryptogams) components. A pilot program was established to test dynamic soil cover modelling techniques. The AussieGRASS model, developed by the Queensland Department of Natural Resources and Mines has been calibrated to estimate total dry matter (TDM) (Carter *et al.* 1996). Dynamic soil cover estimates can be derived from modelled TDM data via equations similar to the ones described for perennial grass pastures by Murphy and Lodge (2002).

METHODS

Annual average cover

The validation data presented are from the 334 Rangeland Assessment Program (RAP) sites monitored annually at similar times of the year over the last 13 years. They were compared with modelled AussieGRASS data for each RAP measurement in space and time. Limitations of the data include: some systematic difference between measured and modelled cover (eg. tree litter measured but not modelled), only one equation per vegetation community to convert TDM to combined plant and litter cover, and climate data availability varies significantly across NSW.

RESULTS & DISCUSSION

The time series of measured and modelled annual average cover values (Fig. 1) follow the same trend, neither diverging or converging over time. This indicates the long term stability of the model.

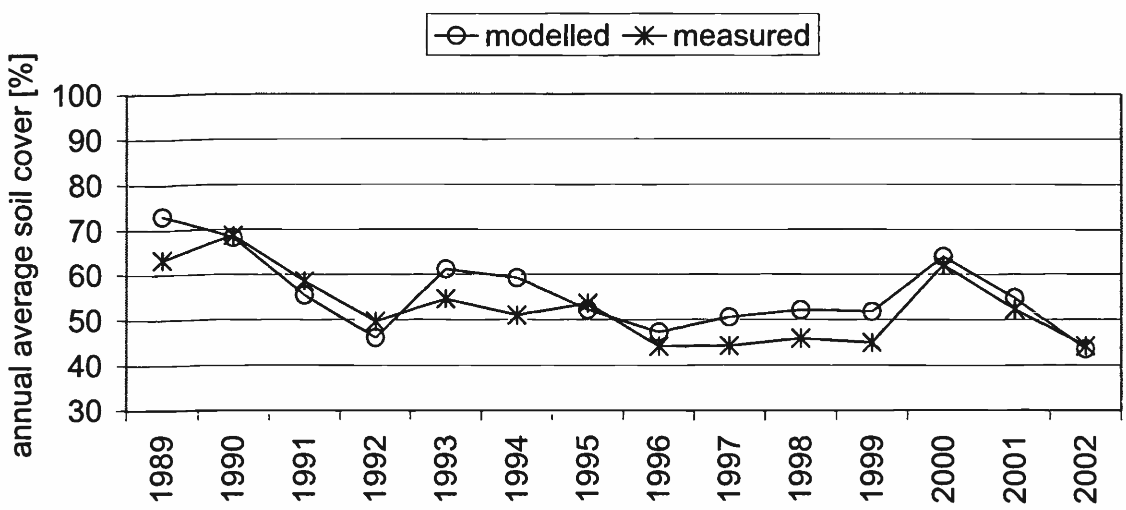


Figure 1: Modelled and measured annual average cover values for all RAP sites as time series.

Annual average cover correlations are in good agreement. Cover values are approximately 5% over-predicted. Trends in measured annual average cover do not necessarily follow trends in measured TDM (eg. 1991/92 and 1998/99). That is, increasing cover does not necessarily correspond with increasing TDM.

Average annual cover is a very coarse measure of soil protection against erosion. It does not quantify the area of a catchment at erosion risk. For instance, an average catchment cover of 40% can be made up from either the entire catchment at 40% cover or half the catchment at 80% cover and the other half bare. The area of the catchment below 40% cover (and therefore at erosion risk) would provide a better catchment indicator.

Area at erosion risk

To determine the area at erosion risk requires the analysis of the distribution of cover across the catchment. Averaging the last 13 years of data, the model estimates 24% of all RAP sites at risk whereas RAP measurements indicate 36% at risk (i.e. sum 0% to 40%). This relation is not as good as the average cover correlation and requires further work. Assuming that the RAP point measurements represent the Western CMA they can be interpreted as CMA areas.

Area at risk through time

As the drought progressed from May 2000 until late 2002, the modelled average cover for the Western CMA (light grey line in Fig. 2) gradually declined. In contrast, the modelled area of the CMA with more than 40% cover (black line in Fig. 2) declined at an increasing rate as the drought progressed. It also revealed seasonal variations in the decline. This highlights the importance of describing the CMA area at risk rather than the average CMA cover when assessing the erosion risk of a landscape.

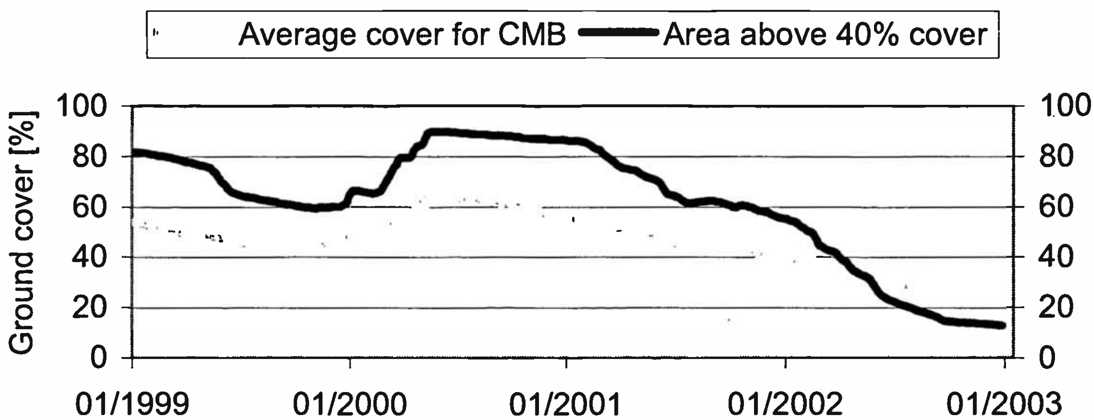


Figure 2: Modelled daily cover data for the Western CMA.

CONCLUSIONS

- AussieGRASS can estimate average ground cover level at a catchment scale.
- Modelling has the advantage of high temporal resolution – it is possible to fill gaps in remote sensing or measurements.
- Modelling can be used in conjunction with climate predictions to forecast cover level.
- Annual average cover is an inadequate tool for determining soil protection against erosion. The area at erosion risk (e.g. <40% cover) is a better indicator of the landscape condition.
- There is a need to develop methods to "add" non-dynamic cover components (e.g. rock).
- Further work is required to determine accuracy at vegetation community scale.

REFERENCES:

Murphy, S.R. and Lodge, G.M. (2002). Ground cover in temperate native perennial grass pastures. 2. Relationships with herbage and litter mass. *Rangeland Journal*, 24: 301-12.

Carter, J.O., et al. (1996). Development of data rasters for model inputs. *In* Development of a National Drought Alert Strategic Information System Volume 3. Final Report on QPI 20 to Land and Water Resources Research and Development Corporation.

PICTURING LANDSCAPE CHANGE IN QUEENSLAND WOODLANDS

M. McCullough [1], S. Bray [2], D. Myles [2], C. Paton [3], M. Rutherford [2] and W. Schulke [4]

[1] DPI&F, PO Box 1085, Townsville, QLD 4810
[2] DPI&F, PO Box 6014, Rockhampton North, QLD 4701
[3] DPI&F, PO Box 118, Gayndah, QLD 4625
[4] DPI&F, PO Box 1143, Bundaberg, QLD 4670

CHANGING WOODLANDS

The woodlands of northern Australia are a significant natural resource, with beef cattle production being the single biggest industry. In Queensland, 60M ha of woodland carry *c.* 2.1M cattle, with annual production worth *c.* $220M per year. They produce 60% of Queensland's sawn hardwood timber and products used on farm (fencing and yard building timber) and are utilised by other primary industries such as bee-keeping. Woodlands contribute to biodiversity, maintenance of landscape function (e.g. hydrological cycle) and are a huge carbon reserve.

The woodlands of northern Australia are changing. There are reports of woody plant thickening and thinning (Burrows 2002, Scanlan 1991, Sharp and Whittaker 2003). Measuring the direction and magnitude of these changes is difficult particularly within remnant 'intact' woodlands that have not been subjected to broad-scale clearing. Factors affecting the woodlands include natural processes (climate, CO_2 enrichment and woody plant dynamics), landholder management (grazing, clearing, harvesting, fire) and external influences (domestic and international policy, vegetation management, greenhouse/carbon accounting). Attempts to characterise these changes have been conducted using direct ground-based monitoring (Burrows *et al.* 2002) and air-photography techniques (Fensham *et al.* 2003). Limitations of these techniques include the short time period they span in relation to modern European-style management and their resolution at site and regional scales.

USE OF PHOTO PAIRS

The paired photograph approach has been successfully used to examine changes in woodlands (Klement *et al.* 2001, Lewis 2002). Although photo pairs cannot provide rigorous, measured, statistically analysed scientific proof, they can provide graphic visual evidence of landscape change and extended assessment time intervals. Paired photographs will be used to complement other more rigorous woodland monitoring techniques. By matching historic and modern day photographs taken at the same site, a body of visual evidence of landscape change will be compiled (Figure 1). In Queensland, photographs date back as far as the 1800s, pre-dating current woodland studies and offering information about changes in woodlands.

Photo pairs will be gathered from each of the 14 regional catchment areas within Queensland (Border Rivers, Burdekin, Burnett Mary, Cape York, Condamine, Desert Channels, Fitzroy, Mackay Whitsunday, Maranoa Balonne, Northern Gulf, South East, South West, Southern Gulf, Wet Tropics). A database of electronic images will be developed containing information to enable future photography at the same site as well as anecdotal information about the observed landscape changes. This will enhance the cost effectiveness of other scientific monitoring processes.

There are high levels of interest in photographic images indicating that this project offers opportunities for broad community involvement. Material may be gathered from both public and private collections.

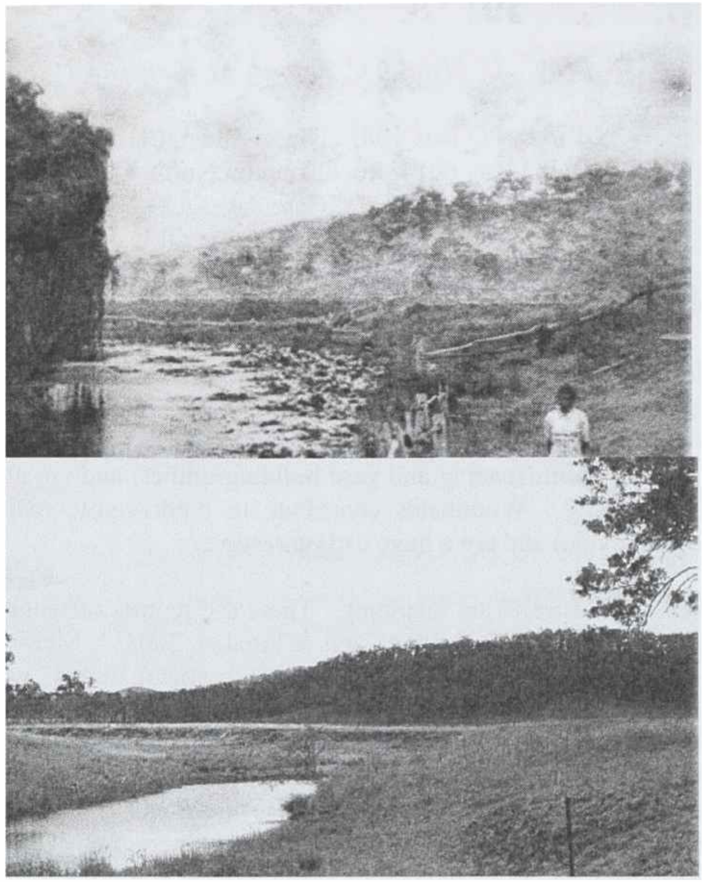


Figure 1. This photo pair was taken near the homestead at 'Booubyjan' in South Eastern Queensland. The old photograph was taken in 1888 and rephotographed in 2002. Vegetation on the hill in the background has become denser. In the foreground, changes to riparian structure are obvious.

REFERENCES

Burrows, W.H. (2002). Seeing the wood(land) for the trees – an individual perspective of Queensland's woodland studies (1965-2005). *Tropical Grasslands* 36: 202-217.

Burrows, W.H., Henry, B.K., Back, P.V., Hoffman, M.B., Tait, L.J., Anderson, E.R., Menke, N., Danaher, T., Carter, J.O. and McKeon, G.M. (2002). Growth and carbon stock change in eucalypt woodlands in northeast Australia: ecological and greenhouse sink implications. *Global Change Biology* 8: 769-784.

Fensham, R.J., Low Choy, S.J., Fairfax, R.J. and Cavallaro, P.C. (2003). Modelling trends in woody vegetation structure in semi-arid Australia as determined from aerial photography. *Journal of Environmental Management* 68: 421-436.

Klement, K., Heitschmidt, R. and Kay, C. (2001). Eighty years of vegetation and landscape changes in the northern great plains: a photographic record. USDA, Miles City, MT 59301.

Lewis, D. (2002). *Slower than the eye can see*. Tropical Savannas CRC.

Scanlan, J.C. (1991). Woody overstorey and herbaceous understorey biomass in *Acacia harpophylla* (brigalow) woodlands. *Australian Journal of Ecology* 16: 521-529.

Sharp, B.R. and Whittaker, R.J. (2003). The irreversible cattle-driven transformation of seasonally flooded Australian savanna. *Journal of Biogeography* 30: 782-802.

KIMBERLEY GRASSLANDS: CHANGE, DRIVERS AND ATTRIBUTION

P.E. Novelly [1,3], *A.B Craig* [1,3], *R.F. McCarthy* [2] *and D.J. Hadden* [1]

Department of Agriculture, [1] Western Australia, PO Box 19, Kununurra WA 6743;
[2] PO Box 278, Derby, WA, 6728 and [3] Tropical Savannas CRC

INTRODUCTION

The Western Australian Rangeland Monitoring System (WARMS) provides change information on pastoral rangelands at broad scales, through a set of representative, point-based sites (Watson and Novelly, 2004). Sites are allocated to vegetation groups (Table 1) based on an index of pastoral productivity, fragility and areal extent. There are 381 grassland sites in the Kimberley, reassessed on a three-year cycle. Ancillary data are collected concerning use of the paddock within which the site is located, as well as nearest rainfall data, evidence of fire and so on.

The Department of Agriculture, Western Australia developed WARMS as part of its process for measuring and reporting on the extent to which rangeland targets are being achieved, with achievement considered some measure of pastoral management. But, performance assessment should be derived from the logic of the relations between causation and the influences that connect actions to ultimate effects. While change may be identified, the more difficult question is one of determining what is driving that change. Attribution is important for providing feedback to management, and separating managerial drivers from natural, uncontrolled drivers such as rainfall is difficult. This paper considers such attribution.

CHANGE

Since 1994, 286 WARMS sites have been assessed on three occasions, with perennial grass frequency generally increasing, albeit from a strong base (Table 1). Note that no distinction is made in this paper as to grass species, and hence pastoral, ecological or other value.

Table 1. Vegetation group and average frequency of perennial grasses (i.e. number of quadrats containing perennial grasses out of 100 quadrats) for all sites in the Kimberley with three assessments.

Vegetation Group	Number of sites	1994 or 1995 or 1996	1997 or 1998 or 1999	2000 or 2001 or 2002
Black Soil	100	74	81	86
Curly Spinifex	52	79	82	85
Coastal Vegetation	10	86	88	81
Frontage Grass	12	68	85	87
Limestone Grass	19	31	36	44
Northern Ribbongrass	17	97	96	98
Southern Ribbongrass	54	78	88	92
Soft Spinifex	22	89	89	91
Total	286			

Site selection is based on encompassing the range of condition states within the local area. However, variation in frequency at the first sampling amongst vegetation groups should not be taken to indicate variation in the initial condition. Rather, as the same quadrat size is used on most sites to prevent confusion, this difference reflects the characteristics of each of the vegetation groups.

DRIVERS OF CHANGE

Undoubtedly, individual paddock management varied across sites within vegetation groups. However, individual site data are aggregated for analysis, and such aggregated data should reflect the drivers at the regional or vegetation community level, rather than paddock or property. Several factors apart from the grazing pressure of domestic stock have, theoretically, affected change over the previous decade. So, what are these regional, or community wide, drivers, and to what extent can attribution of their effects be defined?

Grazing pressure

While heterogeneous across the region and pasture groups, data suggest average cattle stocking rates in the Kimberley in the early 1990s were only around 50% of those ten years previously. Rates remained relatively constant through to the late 1990s, increasing again somewhat in the last few years. Allied to this was a steady decline in grazing from feral animals, particularly feral donkeys. Donkeys had been eradicated from more than 230,000 sq km by late 2003, up from virtually nothing 12 years previously. For a similar control effort, donkey numbers destroyed per annum fell by almost 50% over this period.

Rainfall

Rainfall was low in the late 1980s and early 1990s, especially in the central Kimberley (Halls Creek and Fitzroy Crossing). Halls Creek average rainfall from 1986/87 to 1989/90 was only 368 mm (average 548 mm), with 699 mm in 1990/91 but only 241 mm in 1991/92. In contrast, from 1992/93 to 2000/01, rainfall averaged 726 mm annually, with 1005 mm recorded in 1999/2000. A similar cycle was recorded in other centres, suggesting change from a 'dry' to a 'wet' cycle prior to the decade during which monitoring occurred.

"Coastal Vegetation" change was negative in the latter part of the monitoring cycle. This vegetation is concentrated on the Broome coast where, starting from the 1998/99 wet season, heavy falls associated with cyclones inundated pastures for several months. At one lease, falls in one month exceeded annual rainfall on two occasions between December 1998 and March 2000, with the total rain during this period being 1957 mm (annual mean is 352 mm). The neighbouring lease also recorded rainfall above the annual mean in two separate months, while the total for the period was 2473 mm, with an annual mean of 407 mm.

Fire frequency and intensity

Fires are a significant component of Kimberley grasslands, and like grazing pressure, impact is heterogeneous across the landscape. While only available from 1993, data show fire frequency was low in 1993, then much higher, although variable, subsequently. However, data available on the impact of fire on perennial grass frequency (particularly the interaction of fire and grazing) are limited, thus restricting attribution of this driver.

CONCLUSION

The improvement in perennial grass frequency seen on WARMS sites is encouraging. However, several drivers have potentially contributed to this improvement. The degree to which any one driver is responsible is difficult to determine, as is the impact of possible interaction between drivers. This restricts the conclusions that can be drawn. To enhance the value of WARMS, further research in the area of attribution determination is warranted.

REFERENCES

Watson, I.W. and Novelly, P. (2004). Making the biodiversity monitoring system sustainable: design issues for large scale monitoring systems. *Austral Ecol.* 29: 16-30.

VEGMACHINE – EXTENDING INTEGRATED RANGELAND MONITORING INFORMATION TO INDUSTRY

L. Peel

NT DIPE, PO Box 30, Palmerston NT 0831

ABSTRACT

An increasing number of producers in the Australian rangelands are requesting objective information on vegetation change and condition to assist in property management. It is now generally accepted that this information cannot be supplied from ground-based rangeland monitoring systems alone and that the integration with satellite-based systems is required (Holm 2000).

VegMachine, a practical software toolbox, allows non-technical users to display, interrogate and summarise satellite-based monitoring data for tailored applications. VegMachine builds upon and incorporates research and development in rangeland monitoring conducted in northern Australia (Wallace and Thomas 1999, Karfs *et al.* 2000). It provides a unique opportunity for producers to integrate satellite-based monitoring information and other relevant information (e.g. land resources, infrastructure, and ground-level data) into enterprise level decision making.

VEGMACHINE – A MEAT AND LIVESTOCK AUSTRALIA FUNDED PROJECT

VegMachine allows the producer to easily access satellite images for detecting change in cover over time. The program displays any type of satellite image, aerial photograph, digital topographic map, land resource data, infrastructure (roads, fences, etc) and fire mapping. Producers can view images showing where grazing is occurring and monitor the short and long term effects of their management plan at a watering point to an entire paddock and the whole property. Due to the producers' knowledge of their country and management plans, they can utilise VegMachine to verify the effectiveness of their management. VegMachine can assist a new manager to gain information and awareness of the property quickly and easily.

A range of images are available to suit individual producer's interests, depending on what it is they want to monitor (e.g. grass cover, shrub thickening) and over what time period. Spatial images provide the 'where' cover change has occurred during the time period analysed. Analysis can be over an extended period (e.g. three or more years) using a six-colour cover and trend map to monitor the effects of changed management of, for example, a paddock (see Fig. 1). A simplified three-colour cover change image comparing only two years of satellite data highlights areas of significant change annually. Near real-time MODIS satellite images can be used to monitor vegetation cover throughout the current season. Time-trace graphs provide the user with the ability to interpret cover change in terms of condition and trend with respect to seasonality and management. Time-traces can represent areas of multiple scale from watering point, to paddock to property.

Figure 1 is a view of VegMachine showing a cover trend image on black soil plains in the Victoria River District from 1998 to 2001 (left window), and a time-trace graph of cover levels from 1983 to 2002 (right window). Users can draw a line to select an area of interest (black and orange line work in two different paddocks on the same land type and graph). The program automatically graphs vegetation cover levels of the selected areas and compares these against the regional average (blue line – graph). The centre of the image shows a pronounced fenceline effect and indicates cover within this paddock has increased from a below average level. The black line (graph) shows cover levels have been average to below average in this selected area (compared with regional average). Management has changed stocking levels since 2000 and this has resulted in a marked increase in cover leading to recovery and sustained or increased productivity. The regional average also suggests there has been a steady increase in cover levels for this land type, due to a run of good seasons from 1993 onwards.

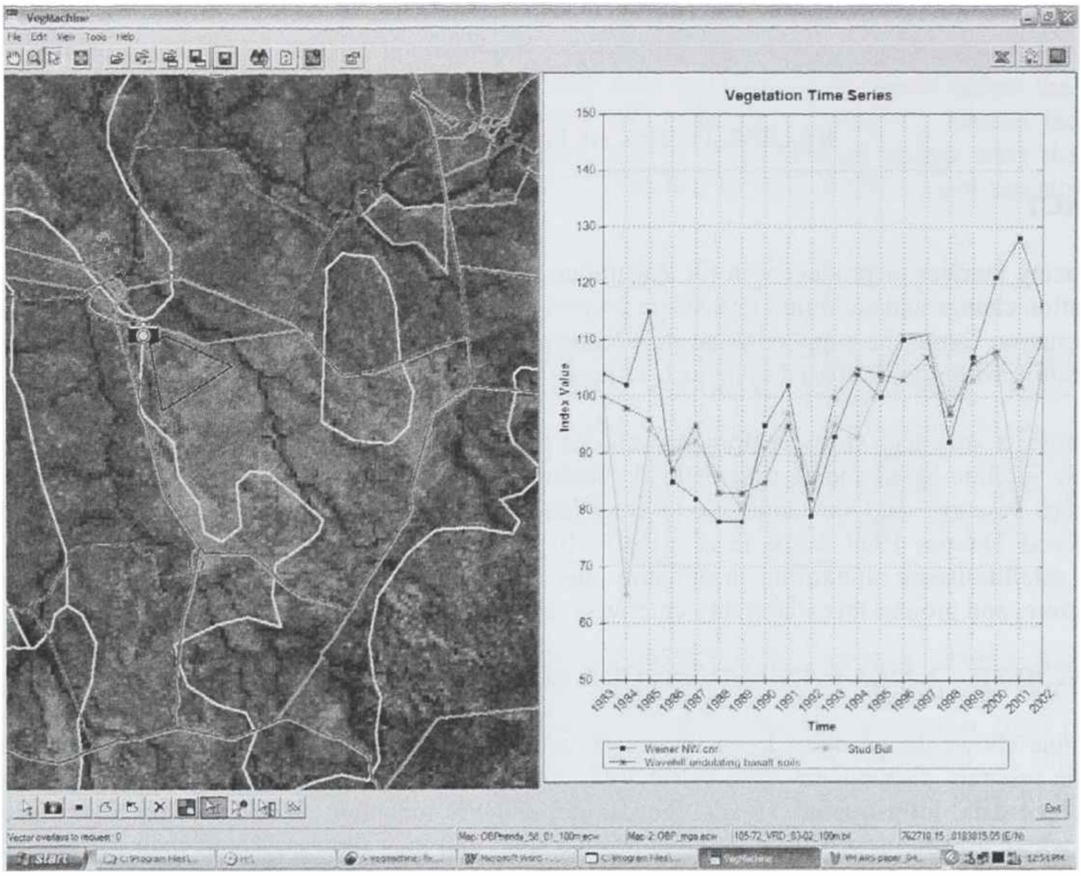


Figure 1. Cover and trend image for 1998 to 2001 and graph of cover levels for selected areas (black and orange lines) and comparison with the regional average (blue line) from 1983 to 2002.

The second area (orange – image and graph) indicates cover levels have remained at or below the average for this land type. This paddock holds the stud bulls for most of the year until required, and is consistently grazed in the favoured area between two creeks. Fire affected cover levels in 1984 and 2001.

By empowering producers with the ability to use data collected by satellites, VegMachine promises to assist producers in monitoring their land and providing information to assess where management changes might be made for maximising economic and environmental benefits.

REFERENCES:

Holm, A. (2000). *Operational Manual: Australian rangeland information system.* National Land and Water Resources Audit. http://audit.ea.gov.au/ANRA/rangelands/docs/project.html

Karfs, R., Applegate, R., Fisher, R., Lynch, D., Mullin, D., Novelly, P., Peel, L., Richardson, K., Thomas, P. and Wallace, J. (2000). *Regional land condition and trend assessment in tropical savannas: The Audit Rangeland Implementation Project Final report.* National Land and Water Resources Audit, Canberra. http://audit.ea.gov.au/ANRA/rangelands/docs/project.html

Wallace, J. and Thomas, P. (1999). Monitoring and summarizing rangeland changes using sequences of Landsat data. *People and Rangelands: Building the Future (Eds D. Eldridge & D. Freudenberger)*, pp. 777-778. Proc. VI International Rangeland Congress, Townsville, July 19-23. VI International Rangeland Congress Inc., Townsville, Australia.

CHARACTERISATION OF PHOTOSYNTHETIC ORGANISMS USING GREENNESS INDEX (NDVI) TIME TRACES FOR THE FORTESCUE FIVER FLOODPLAIN

M. Tovar, S. Maier, R. Smith and M. Steber

Satellite Remote Sensing Services - Department of Land Information
65 Brockway Rd, Floreat WA 6014

The Fortescue River floodplain in the Pilbara region of Western Australia is subject to periodic flooding during the summer months, especially during the months of January and February.

Flood conditions on the grazing areas could last for up to a fortnight, and large volumes of water may sit in the so-called Fortescue Basin for most of the year.

Vegetation responses after a flood/rain event are sometimes difficult to evaluate on the ground due to poor access. Satellite derived vegetation indices have been used in Australia to describe vegetation responses on the rangelands for over ten years (Smith 1994).

The widely used Normalised Difference Vegetation Index (NDVI) is a robust vegetation index that has been correlated with the rate of photosynthetic activity (Tucker and Sellers 1986). Long term NDVI data sets have been generated at one kilometre ground resolution for the production of maximum value NDVI composites on a fortnightly or monthly basis. This has been the convention for a number of Australian organisations, such as the Department of Land Information from Western Australia.

However, single date nadir/near nadir NDVI observations might better explain floristic changes than fortnightly image composites for a local area, such as those occurring on semi-arid floodplains. In the Fortescue River floodplain, diverse photosynthetic organisms responded at several rates to mesic conditions.

NDVI data from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra and Aqua satellites offer the opportunity to generate NDVI time traces at 250 m ground resolution and characterise adequately photosynthetic soil cyanobacteria crust, annual herbs and forbs from the perennial component. The length, position and shape of a NDVI curve for microphytic crust over a number of seasons have potential to be an environmental and management indicator in the arid environment. Microphytic organisms play an important function in soil stabilisation, nitrogen fixation and water infiltration (O'Neil 1995).

REFERENCES

O'Neil, A. (1995). Spectral monitoring of climate change. Paper presented to the 1995 International Symposium on Spectral Sensing Research (ISSSR), 1995. Melbourne, Australia.

Smith, R.C.G. (1994). *Australian Vegetation Watch.* Remote Sensing Application Centre, DOLA. Western Australia, pp. 103.

Tucker, C.J. and Sellers, P.J. (1986). Satellite remote sensing of primary production. *International Journal of Remote Sensing* 7: 1395-1416.

THE IMPACT OF RECENT DRY SEASONS ON SHRUB AND TREE DYNAMICS: RESULTS FROM THE WESTERN AUSTRALIAN RANGELAND MONITORING SYSTEM (WARMS)

Ian Watson [1], Philip Thomas [2], Wayne Fletcher [1] and Kerry Skinner [1]

[1,2] Centre for Management of Arid Environments and Department of Agriculture Western Australia
[1] PO Box 483, Northam, Western Australia, 6401
[2] Locked Bag No. 4, Bentley Delivery Centre, Western Australia, 6983

ABSTRACT

The numbers and canopy size of shrubs and trees increased on the majority of Western Australian Rangeland Monitoring System (WARMS) sites in the arid and semi-arid shrublands of Western Australia over the last decade. Recruitment of new individuals was commonplace. Recruits were observed on almost all sites and for the majority of species. About 40% of the sites were reassessed within an area declared for Exceptional Circumstances. While there were some negative impacts from the combination of pastoralism and dry seasons, they were not catastrophic, as has been previously observed following severe drought.

INTRODUCTION

The premise behind WARMS is that changes in the condition of the rangelands can be indicated by changes in the health of the perennial vegetation and that WARMS sites provide a stratified sample of the rangelands grazed by domestic stock. In general, an increase in shrub numbers and canopy size is seen as an improvement, although this will depend on the values placed on particular species.

A prolonged dry period across much of the southern rangelands of Western Australia began in 2000 and continued through 2001, 2002 and 2003. The dry period resulted in much of the region being declared for Exceptional Circumstances. History shows that severe droughts have result in extensive degradation (McKeon *et al.* 2004). This paper summarises changes observed on WARMS sites over the last decade, including during the prolonged dry period, in order to determine to what extent degradation had occurred.

METHODS

Between July 1999 and October 2003, 711 WARMS sites were reassessed on 240 leases (i.e. about 74% of leases in the southern rangelands of WA). These sites were installed between December 1993 and June 1999. The average time between installation and reassessment was five years. On each site, the dynamics (i.e. recruitment and survivorship) of the shrub and tree populations were tracked using direct census. That is, the final number of plants was derived from the initial number, plus recruitment, minus deaths. Additionally, canopy dimensions (i.e. width and height) of all individuals were assessed. A general description of WARMS is given in Watson and Novelly (2004). The data set comprised about 104,000 individual plants and about 200 species.

The data were summarised for each site by comparing (1) shrub and tree numbers at reassessment, with numbers at installation; and (2) canopy size, taken as the sum of the canopy width and height, between installation and reassessment. Note that the maximum estimated canopy height was 205 cm.

To investigate the impact of the dry seasons, the sites were divided into three groups based on the date of reassessment and whether or not the lease was within the area submitted to the Commonwealth Government for Exceptional Circumstances. Of the 711 sites, 410 were either outside the EC declared (ECD) area, or were assessed before 1/8/01, i.e. before the impact of the dry seasons (Group1). Group 2 consisted of 151 sites that were in the ECD area and were reassessed between 1/8/01 and 1/8/02, i.e. in the early part of the dry period. Group 3 consisted of 150 sites in the ECD area and reassessed between 1/8/02 and 11/10/03, i.e. further into the dry period. Note that while sites in Groups 2 and 3 were reassessed during the dry period, they were all installed prior to July 1999, in years when rainfall was higher.

RESULTS AND CONCLUSIONS

The dry seasons had a negative impact on shrub and tree populations. However, the impact was not large, certainly not catastrophic, except on a few isolated sites. While such a result can generally be viewed as "good news", it may also be that the full impact of the extended dry period had not expressed itself by the time the sites were reassessed, even though Group 3 sites had experienced three or four consecutive dry winters.

For those sites either outside the EC area, or which were reassessed before the impact of the dry period (Group 1), shrub and tree populations remained the same or increased on 87% of sites by an average of 54% (Table 1). Both statistics were less for sites in the ECD area during the dry period (Groups 2 and 3). For Group 3, around half the sites (46%) showed increased or identical populations and half decreased. The average change in numbers was close to zero (-1%). The pattern for canopy size was similar with a negative impact in the ECD area during the dry period.

Table 1: Summary of changes found on 711 WARMS sites. Group 1; Either not ECD or ECD but reassessed before 1/8/01 (410 sites). Group 2; ECD and reassessed between 1/8/01 and 1/8/02 (151 sites). Group 3; ECD and reassessed between 1/8/02 and 11/10/03 (150 sites). For the "Average change (%)", (i.e. rows two and four) 0% equals no change and 54% equals an increase of 54% from baseline.

	Group 1	Group 2	Group 3
Percent of sites with same or increased shrub and tree numbers	87%	66%	46%
Average change (%) in shrub and tree numbers by site	54%	10%	-1%
Percent of sites with same or increased total canopy size	98%	89%	53%
Average change (%) in total canopy size by site	38%	16%	3%

Across all sites, recruitment of new shrubs was commonplace, with at least some new individuals being recorded on 99% of sites, irrespective of whether ECD or sampled in the dry period. Recruits found on sites that were assessed well into the dry period (Group 3) almost certainly germinated during earlier wetter periods. Recruitment was observed for 80% of all species recorded and 100% of species with an initial population of at least 20.

These results suggest that pastoral activities during a very dry period did not have region-wide severe impacts on shrub and tree populations, at least on WARMS sites within those areas reassessed. However, we note that pastoral lease inspections within the region have identified some leases where unacceptable impacts have occurred over the same period. We also note that should the dry period continue through 2004, the scale of negative impact will almost certainly increase.

ACKNOWLEDGEMENTS

WARMS is a core funded activity of the Department of Agriculture Western Australia.

REFERENCES

McKeon, G.M., Hall, W.B., Henry, B.K., Stone, G.S. and Watson, I.W. (2004). *Pasture degradation and recovery in Australia's rangelands: learning from history.* Queensland Department of Natural Resources, Mines and Energy. Natural Resource Information Publishing, Brisbane.

Watson, I.W. and Novelly, P. (2004). Making the biodiversity monitoring system sustainable: design issues for large scale monitoring systems. *Austral Ecol.* 29: 16-30.

CYANOBACTERIA – SILENT SURVIVORS DURING DROUGHTS

Wendy J. Williams

University of Queensland, Gatton, QLD 4343

INTRODUCTION

Cyanobacteria are well renowned for their survival strategies in harsh environments and can tolerate long periods of desiccation resulting from acute water deficiency (Wynn-Williams 2000). Cyanobacteria in soil crusts play a crucial role in maintaining soil surface stability (Danin *et al.* 1989), particularly when other vegetation is absent. Many cyanobacteria are capable of fixing atmospheric nitrogen (West 1990), contributing significant nutrient to the surrounding substrate which is readily taken up by vascular plants, fungi, actinomycetes and bacteria (Belnap 2003).

The recent drought in Australia has resulted in some of the most devastating pastoral conditions during the past century. Over the past two years I have been monitoring the cyanobacteria-dominated biological soil crusts at 'Glencoban' in south-western Queensland. The 2000 ha paddock normally carries a mix of cattle and sheep but was completely destocked in early 2003 due to severe drought conditions. Early in 2002, a distinct gradient was observed in the distribution of biological soil crusts, expressed as a significant increase in soil crust cover with increasing distance away from water points (Williams, unpublished, 2002). This gradient of crust cover was attributed to grazing pressure. Since that time a gradual decline in crust cover has been recorded along these transects. At some points however, crust cover has increased.

Early in 2003 rainfall runoff from local thunderstorms washed sand downslope, exposing substantial portions of the biological soil crust that had been previously covered by sand. The exposure of the cyanobacteria beneath the sand suggested that the amount of soil crust visible was not a true reflection of the total amount present. In order to improve methods for the detection of crust cover, a series of transects were used to determine whether there were predictable differences between the exposed cyanobacterial soil crust and layers of crust covered by sand.

METHODS AND RESULTS

Six 10-m transects were located adjacent to established transects in run-off zones. Many of the extremely rocky zones had not trapped or retained sand cover, so the transects were located somewhere between these rocky ridgelines and mulga grove run-on zones. These regions appeared to be where sand deposits, transported into the area predominantly by wind and water, were most abundant. The cyanobacterial soil crust that was visible on the surface was recorded along each transect. Following this, the sand was brushed away to expose any further soil crust surviving underneath and once again the crust cover was recorded.

The average cyanobacterial crust cover, exposed and visible on the surface, from six 10-m transects was 8.5% (se = 3.1). On these same transects the average crust cover found underneath the sand was 37.2% (se = 2.6). Using a paired *t*-test, the average difference of 28.7% (se = 3.4) was highly significant ($p < 0.001$).

Visually, the cyanobacterial crust underneath the sand appeared to be faded and not as robust in structure compared to photographic records of the same crusts taken in the early stages of the drought. Erosion or ablation had reduced the crust continuity previously observed. Subsequently, following significant rainfall, cyanobacteria and the other crust organisms in both the exposed areas and areas that had been covered by sand have been extremely active, as indicated by their ability to photosynthesise.

DISCUSSION

In this erosionally active landscape where sand is continually being moved throughout the region by wind and water, these results indicate why estimates of cyanobacterial crust cover vary widely over short time spans. Some of the decline in cover recorded may merely reflect the deposition of sand gradually covering the exposed cyanobacterial crusts. It would seem reasonable to suggest that the majority of the cyanobacterial crust structure has remained intact throughout the drought. The cyanobacterial soil crusts are physically fragile and easily broken up by stock trampling. The destocking of this paddock occurred at a crucial time, preventing further damage to these crusts.

Cyanobacteria are important for the long-term sustainability of rangelands. Growth, photosynthesis and nitrogen production in cyanobacteria are triggered by even small rainfall events (Lange *et al.* 1998). Cyanobacteria are capable of photosynthesis in extremely low light conditions (Lange 2003). It is quite possible that the sand cover is not extinguishing, but merely slowing, the photosynthetic processes. Small amounts of light have been shown to penetrate sand cover of up to three cm in depth (Williams, unpublished data). When combined with moisture from dew or small rain events cyanobacteria may remain sporadically active even during extended drought conditions.

The fact that substantial patches of cyanobacteria dominated soil crust have survived under layers of sand over the past two years of severe drought indicates that cyanobacteria are well adapted to survive periods of frequent sand inundation. Although microscopic, cyanobacteria in soil crusts play a crucial role in providing soil surface stability. In times when environmental stresses impact on the bare ground during drought the cyanobacterial crusts act as a biophysical barrier. Consequently, it is paramount that the monitoring and management of these biological soil crusts should be integrated into land management practices. For example, the integrity of biological soil crusts should be a factor in determining the appropriate time to de-stock during long dry periods.

REFERENCES

Belnap, J. (2003). Nitrogen fixation in biological soil crusts. *In* 'Biological soil crusts: structure, function and management.' (Eds. J. Belnap and O.L. Lange). Springer, Germany, pp. 241-261.

Danin, A., Bar-Or, Y., Dor, I. and Yisraeli, T. (1989). The role of cyanobacteria in stabilisation of sand dunes in Southern Israel. *Ecologia Mediterranea* XV: 55-64.

Lange, O.L. (2003). Photosysnthesis of soil-crust biota as dependent on environmental factors. *In* 'Biological soil crusts: structure, function and management.' (Eds. J. Belnap and O.L. Lange). Springer, Germany, pp. 217-240.

Lange, O.L., Belnap, J. and Reichenberger, H. (1998). Photosynthesis of the cyanobacterial soil-crust lichen *Collema tenax* from arid lands in southern Utah, USA: role of water content on light and temperature responses of CO_2 exchange. *Functional Ecology* 12: 195-202.

West, N.E. (1990). Structure and function of soil microphytic crusts in wildland ecosystems of arid and semi-arid regions. *Adv. Ecol. Res.* 20: 179-223.

Williams, W.J. (unpublished, 2002). Recovery of the cryptogamic soil crusts and the relative importance of cyanobacteria on semi-arid rangelands near Cunnamulla, Queensland. *Honours thesis*. University of Queensland.

Wynn-Williams, D.D. (2000). Cyanobacteria in deserts - life at the limit? *In* 'The ecology of cyanobacteria. Their diversity in time and space.' (Eds. B.A. Whitton, M. Potts). Kluwer Academic Publishers, The Netherlands, pp. 341-366.

General

(Poster Group Eight)

USING GIS AND SATELLITE IMAGERY TO ESTIMATE THE HISTORICAL EXPANSION OF GRAZING COUNTRY IN THE DALRYMPLE SHIRE

B.N. Abbott and R.R.J. McAllister

CSIRO Sustainable Ecosystems, Davies Laboratory, PMB Aitkenvale Qld 4814

INTRODUCTION

In the 1860s when pastoral enterprises were first established in the Dalrymple Shire, cattle were managed using an open-range system, with low inputs and low outputs (Allingham 1976). Despite the shire's vastness, the area available to pioneering graziers was restricted by proximity to water. The establishment of artificial water points, and changing from the European (*Bos taurus*) to Brahman (*Bos indicus*) cattle breed have substantially eased this restriction. As for other cattle grazing districts, the Dalrymple Shire is rich with anecdotal accounts of the impact of changing technologies, but little quantitative evidence exists. The focus of recent rangelands research has expanded in both temporal and spatial scale. Concurrently, new modelling methodologies have sought to capture these extended scales (Gross *et al.* 2004). To support this new research, historical quantitative data are required to provide an empirical benchmark. Here we used remote sensing, combined with GIS, to estimate how cattle breed and proximity to water have historically changed available grazing land within the shire.

APPROACH AND RESULTS

Our general approach was to estimate water availability at a point of time, then select all land within an assumed grazing radius of water, the radius being based on whether European or Brahman cattle dominated at that period. For our grazing radii we used unsubstantiated anecdotal ranges of two km for European and ten km for Brahman cattle respectively. Water is not limited in the shire's average wet season, so we only considered dry season water availability, which we estimated using Normalised Difference Water Index (NDWI) and manual analysis of Landsat TM 7 satellite imagery (October 2002). We categorised permanent water points into natural (swamps and water courses) and human-made (dams/tanks). Each category was then given a two or ten km buffer zone for grazing effect of European and Brahman cattle respectively. We assumed that only natural water points were available to pioneering graziers. Nowadays, dry season water is supplemented by artificial water points which have increased the grazing area for cattle. We used anecdotal and quantitative records to estimate the transition between an open-range system with European cattle to the present day system dominated by Brahman cattle which are less restricted by proximity to water (Figure 1).

DISCUSSION

Intensification of primary production is a common feature world-wide. In water limited extensive grazing systems such as the Dalrymple Shire, technologies that attempt to overcome water shortages, including dams and selective cattle breeding, have entirely changed the nature of land use in the region. Crude estimates of stocking rates in the Dalrymple Shire show a steady increase in intensity since 1887. When we adjust these stocking rates using our estimates of land within dry-season grazing radii, we see that stocking rates are much more stable. Even though we require some crude assumptions, this analysis provides us with a benchmark over a broad spatial and long temporal scale. This work represents an important input into the CSIRO Emerging Sciences Area - Complex Systems Science funded project "Adaptation and resilience in rangeland social-ecological systems".

(a) (b) (c) (d)

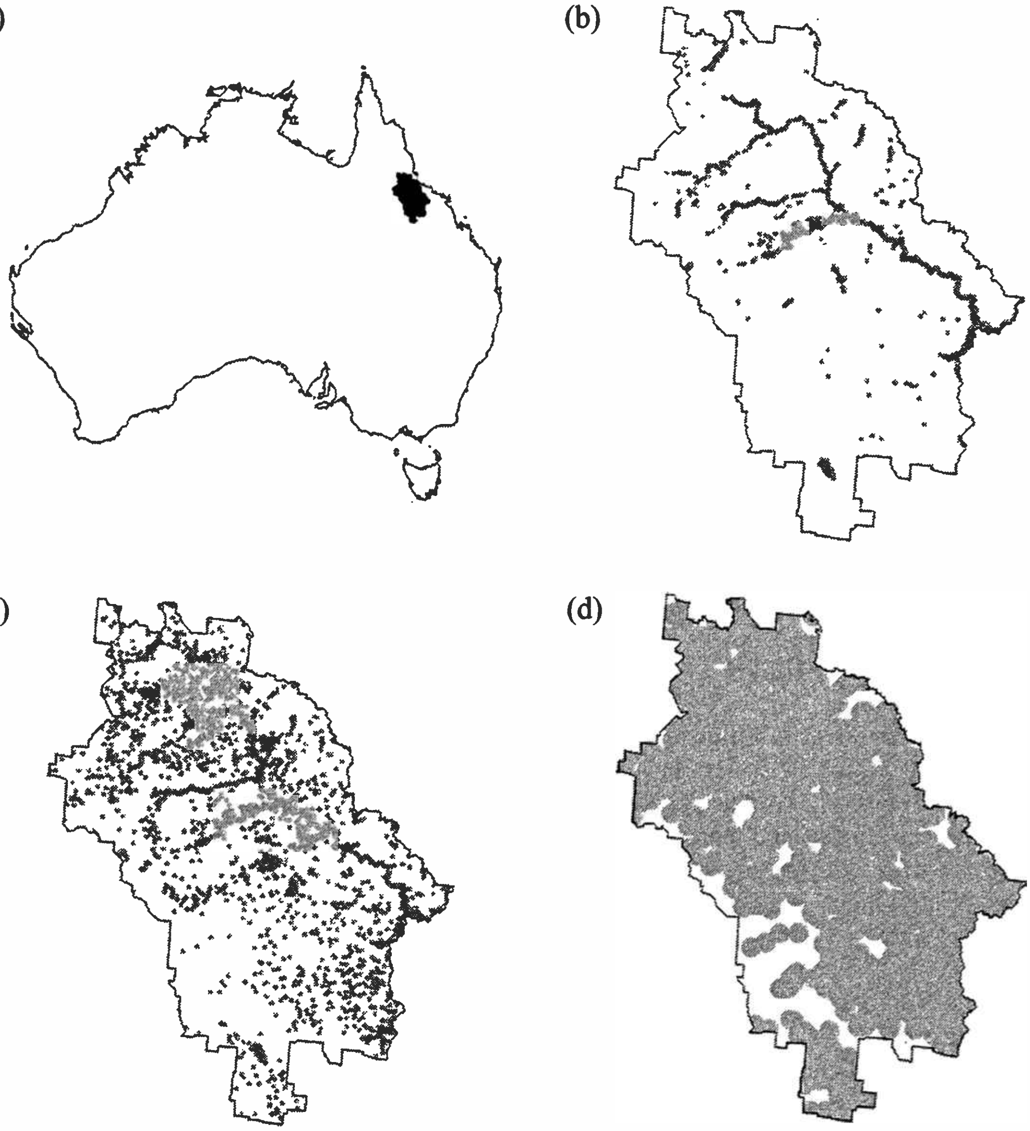


Figure 1. Geographic information maps showing estimated land available for cattle grazing in the Dalrymple Shire under various assumptions representing different eras in pastoral development: (a) Dalrymple Shire location map; (b) pioneering era, with permanent natural water courses and swamps only and European cattle breeds (9% of total area available); (c) pre-Braham era, with permanent natural water courses, swamps, tanks and dams but still European cattle breeds (29%); and (d) with permanent natural water courses, swamps, tanks and dams and Brahman cattle breeds (88%). For additional figures see www.cse.csiro.au/research/cabm/cars.htm.

REFERENCES

Allingham, A.J., (1976). Taming the Wilderness: the First Decade of Pastoral Settlement in the Kennedy District. PhD Thesis, James Cook University of North Queensland, Townsville.

Gross, J.E., McAllister, R.R.J., Abel, N., Stafford Smith, D.M. and Maru, Y. (2004). Australian rangelands as complex adaptive systems: A conceptual model and preliminary results. *Environmental Modelling and Software*, in press.

SPATIAL AUDIT OF RANGELANDS REMOTE FROM WATER

Amanda Brook, Mike Fleming and Frank Kutsche

Pastoral Program, SA Department of Water, Land and Biodiversity Conservation,
GPO Box 2834, Adelaide, SA 5001

INTRODUCTION

The pastoral lease region of South Australia comprises an extensive area of native vegetation used primarily for sheep and cattle grazing. A spatial audit of the pastoral lease lands is currently being carried out to identify and quantify areas remote from water. The catalyst for this work was the delegation to regulate clearance of native vegetation by stock grazing under the *Native Vegetation Act 1991,* from the Native Vegetation Council, to the Pastoral Board within the pastoral lease areas of South Australia. The Native Vegetation Act prohibits the grazing of native vegetation in areas that have not been regularly grazed in the past. This has focussed attention on the installation of new water points. New water points can only be installed once exemption to the Native Vegetation Act has been obtained, through developing a water point plan and having this plan approved by the Pastoral Board.

To assist in the assessment of proposed new water points, information is required about the type and extent of rangeland remote from water. In the absence of a direct measure of grazing activity, remoteness from water is used to model potential grazed area. The relationship between grazing by domestic stock, native and feral animals is well known with grazing activity shown to decrease with increasing distance away from water points.

This poster presents preliminary results on the extent of areas remote from water by Interim Biogeographic Regionalisation for Australia (IBRA) regions, sub-regions and land systems. In addition to assisting with the assessment of proposed waters on pastoral leases, this information will also assist in prioritising areas for biodiversity conservation at a regional scale.

METHODS AND RESULTS

Remoteness from water layers were produced using data from the Pastoral Program's geographic information system (GIS), following the methods used in Biograze (2000). These data comprise fence line and water point information collected or verified in the field using GPS during the pastoral lease assessment program between 1990 and 2000. Fence line and water point data for 221 stations were appended and edge matched (see Table 1). Although the mapping is the most up to date available, it is not current. Since completion of the assessment program, updates have occurred opportunistically. However new waters and fencelines have been established, particularly in the cattle areas, north of the dog fence. Fortunately, these areas are also the most recently mapped.

Table 1. Preliminary numbers of paddocks and waters for sheep and cattle properties in the pastoral lease area of South Australia.

	Number of properties	Number of paddocks	Number of waters
Sheep	171	5,204	11,538
Cattle	50	1,005	5,364

A critical decision affecting the creation of the remoteness from water layers was the selection of the water points to include in the analysis. A classification of water points is not currently available and is problematic, as the focus for grazing of individual water points can change over time. To ensure accuracy throughout the dataset, it was necessary to include all stock watering points. Hence the audit includes ephemeral waters as well as waters no longer active. This is consistent with the approach of

Biograze (2000) and Brook *et al.* (2001). Brook *et al.* (2001) demonstrated that ephemeral waters experience significant grazing impact.

Fence line and water point data were converted from vector into raster data of 50 metre cell size. All water points within 50 metres of a fence were shifted so they were included in the remoteness from water layers produced. Using ESRI software, two remoteness-from-water layers were created, one using fence lines as barriers and one without fence lines as barriers. For both layers, remoteness from water was calculated to 50 km from water. Extensive error checking was then performed. Selected properties were excluded from the audit where topography precluded the application of remoteness from water modelling.

In order to identify the type and extent of areas remote from water, a spatial layer representing biodiversity was required. IBRA regions, sub-regions and Pastoral Program land systems were chosen as surrogates for biodiversity. The choice of these data to best represent biodiversity was made in conjunction with staff from the South Australian Department for Environment and Heritage. Remoteness from water analysis was carried out using the IBRA regions and sub-regions, in accordance to the Australian Guidelines for Establishing the National Reserve System (Environment Australia 1999). Secondly, to provide the finer detail required for decision-making at a property scale, analysis was carried out using land systems.

Land system mapping was selected from other available mapping, including vegetation community and geological mapping, as it is available for the entire pastoral lease area. Importantly, pastoralists are more familiar with land systems mapping than other data. However, the land system mapping varies in scale and accuracy between Soil Conservation Districts. To improve the accuracy of land system mapping, mapping was updated based on the methods described in Brook *et al.* (2001).

Analysis of remoteness from water was carried out for all IBRA regions, sub-regions and land systems in the pastoral lease area.

CONCLUSIONS

The trigger for this work was the delegation to the Pastoral Board to regulate clearance of native vegetation by stock grazing under the Native Vegetation Act, in the pastoral lease areas of South Australia. However, since initiating the spatial audit, there has been much wider interest in the information produced. Quantification of land types and the extent of remoteness from water will:

- Assist in setting regional biodiversity conservation priorities.
- Provide information relevant to the Comprehensive-Adequate-Representative (CAR) principles.
- Provide information for catchment management.
- Provide information to assist in studies of plant and fauna relationships in relation to grazing activity.

Further refinement of the modelling method is envisaged. Some potential improvements include: the use of current water point and fenceline information, taking topographic effects into account, and the application of specific distances to land types, to more accurately identify areas remote from water and grazing.

REFERENCES

Biograze (2000). *Biograze: Waterpoints and Wildlife.* CSIRO, Alice Springs. 13pp.

Brook, A., Tynan, R. and Fleming, M. (2001). *Indices of change in ecosystem function (cover) for northern South Australia using Landsat TM.* National Land and Water Resources Audit Rangelands Project Report, Canberra.

ASTREBLA MORTALITY IN QUEENSLAND AFTER THE 2002 DROUGHT

David H Cobon [1], *Janelle N Park* [2] *and Kerry L Bell* [1]

[1] Predictive and Precision Systems, DPI&F, PO Box 102, Toowoomba Q 4350
[2] Predictive and Precision Systems, DPI&F, PO Box 519, Longreach Q 4730

ABSTRACT

The adjusted mean frequency of live Mitchell grass (*Astrebla* spp.) in western Queensland grazed by sheep, cattle and large macropods declined from 75 to 45% between 2002 and 2003, following a nine year period of stability. Similar declines occurred in sites exclosed from domestic animals and large macropods. Therefore, it is unlikely that the grazing pressure in the last decade caused the mortality. As the period of decline occurred during the worst drought on record, water stress is the most likely cause.

INTRODUCTION

The Mitchell grass (*Astrebla* spp.) area of Queensland covers 32.8 million hectares (19% of Queensland). The native grasses are resilient under grazing and usually respond well to good summer rain. However, for many parts of western Queensland the 2002 El Niño produced the worst drought on record. Grazing pressure comes from domestic animals and kangaroos. This paper reports the findings of monitoring Mitchell grass at up to 69 sites for a 10-year period between 1994 and 2003.

METHODS AND RESULTS

The monitoring sites were located on six properties located around the towns of Longreach and Muttaburra in the central Mitchell grasslands, and Richmond and Julia Creek in the northern Mitchell grasslands. A total of 69 monitoring sites, each 30 sq m were erected in 1994/95 and were in paddocks either grazed by sheep, cattle and large macropods (TGZ), or exclosed from sheep and cattle grazing (e.g. grazed by large macropods, DEX), or exclosed from all grazing (TEX). Between 1994 and 2003 measurements of pasture yield, frequency of live *Astrebla* and ground cover were recorded. Numbers of macropods (red kangaroo, eastern grey kangaroo and common wallaroo) were taken from helicopter surveys that were flown along permanent transects at Julia Creek and Longreach each year. Domestic animal stocking rates were taken from property paddock records. Monitoring of sites occurred at the end of each pasture-growing season (April-August). Pasture yield and ground cover were measured using visual appraisal with the aid of photostandards. Black, pedestalled tussocks that were dislodged from the soil when kicked with a force approximately equal to kicking a soccer ball ten metres were recorded as dead. Samples of these plants were collected and double staining with tetrazolium and Evans blue confirmed they were neither alive nor dormant.

Queensland's Mitchell grasslands experienced moderate drought in 1994-96, a near record wet season in 1999/2000 and the driest year on record in 2001/02 (Figure 1). There was an apparent decline in both the adjusted mean frequency of live *Astrebla* and mean ground cover % between 2002 and 2003 (Figure 2). The reduction in adjusted mean frequency of live *Astrebla* tussocks between 2002 and 2003 was: TRZ (75 to 45%), DEX (80 to 46%) and TEX (63 to 53%), however this decline was not consistent across all properties. Mean ground cover declined from 44 to 22% (TGZ sites), 58 to 37% (DEX sites) and 67 to 45% (TEX sites) between 2002 and 2003. Macropod numbers from 1994 to 2003 averaged 23 per sq km, comprising of 10 (range 6-20) per sq km in the open downs at Julia Creek and 36 (range 18-53) per sq km in shaded downs at Longreach (Figure 2). Mean stocking rate of domestic animals in the paddocks where the sites were located was 0.88 dry sheep equivalent/ha (annual range was 0 to 1.8 DSE/ha).

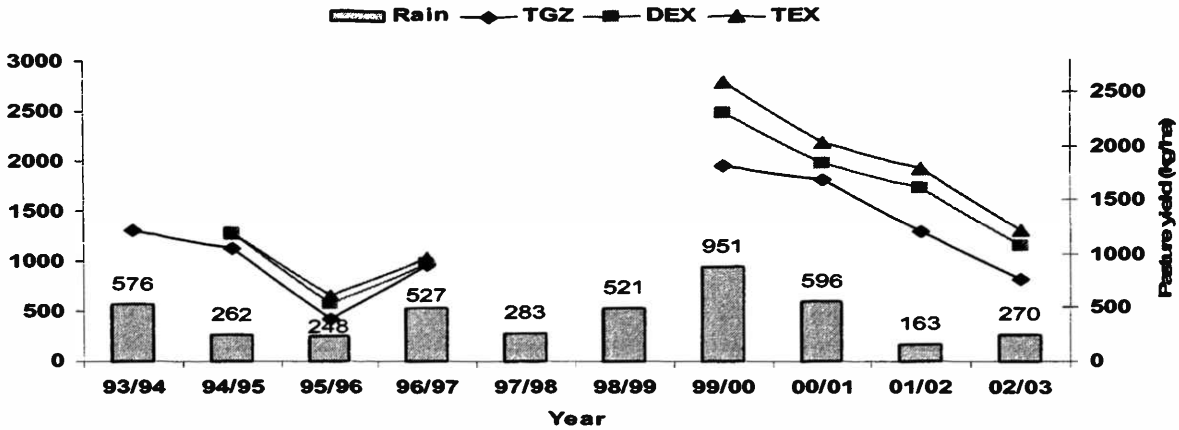


Figure 1. Rainfall at Winton (June-May) and adjusted mean pasture yield for grazed sites (TGZ), sites where domestic animals were exclosed (DEX) and sites where all large animals were exclosed (TEX).

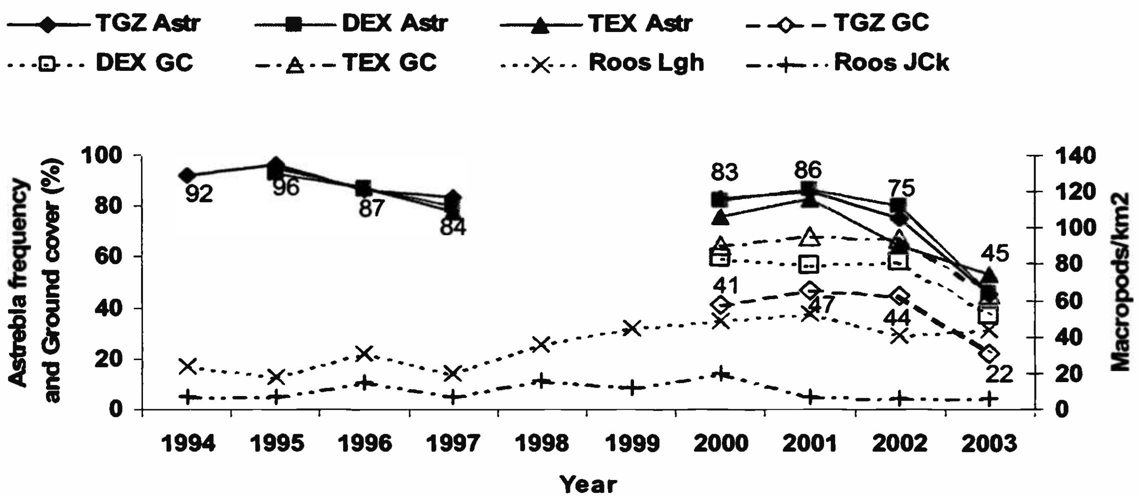


Figure 2. Adjusted mean frequency of live *Astrebla* (Astr) and ground cover (GC) for grazed (TGZ), domestic animal (DEX) and large animal (TEX) exclosed sites, and macropod numbers for Longreach (Roos Lgh) and Julia Creek (Roos JCk). Data labels show Astr and GC values for grazed sites.

DISCUSSION

There was no apparent difference in Mitchell grass survival between sites experiencing different grazing pressures for the previous 10 years. Mean grazing pressures (domestic animals plus kangaroos, 1 DSE equals 0.8 kangaroos) of TGZ, DEX and TEX sites were 1.1, 0.18 and 0 DSE/ha respectively, but were as high as 2.2 (TGZ, Longreach) and 0.42 (DEX, Longreach), and as low as 0.14 (TGZ and TEX, Longreach) in some years. This level of grazing pressure had no adverse impact on the survival of Mitchell grass tussocks in 2003. The death of Mitchell grass is likely to reduce livestock production in the short-term, but anecdotal evidence suggests these pastures have recovered from previous droughts (eg. 1969) and the long-term outlook may depend on a sequence of good years (eg. 1971/72 to 1976/77).

The resilience of Mitchell grass was shown by its survival during the 1994-96 drought, and the severity of the 2002 drought was demonstrated by the mortality of Mitchell grass. However, the variation in mortality that occurred between properties needs further investigation.

ACKNOWLEDGEMENTS

The authors thank the National Landcare Program for funding; the Environmental Protection Agency for macropod helicopter survey data; and DPI&F staff for data collection and analysis.

GRAZIERS, POST-GRADUATE STUDENTS AND LAND MANAGEMENT IN SEMI-ARID NSW: THE EXPERIENCE OF A DECADE OF INTERACTIVE TEACHING FIELD TRIPS

Patricia Fanning and John Pickard

Graduate School of the Environment, Macquarie University, NSW 2109

Understanding the challenges facing land managers in the rangelands of New South Wales is the primary objective of 'Semi-arid Land Management', a unit of study we run in the postgraduate Environmental Management coursework program at Macquarie University. Teaching about land management in remote, regional and rural Australia to urban dwelling students is unrealistic without talking to the land managers themselves. So we take the students out of their comfort zone and put them literally face-to-face with the land and its people, allowing them to re-examine their preconceptions with the help of those who live and work there. At the same time the graziers are confronted with the views of those who judge them and the landscape, carrying with them romantic notions of the Outback mixed up with book-learnt knowledge of a century of land degradation.

Grazier Mark Etheridge talking with students about the Total Grazing Pressure exclosure erected on his property *Kalyanka*, near Wilcannia, NSW.

The core of the unit is a six day field trip to the White Cliffs – Wilcannia area of western NSW. Each day, we travel with the landholders, see something of the landscape and the property management, and talk with them about what they do and why. Student assessment is via an oral presentation out in the paddock in front of the landholder, an integrative report on land management, and an essay in which the students discuss how their perceptions of semi-arid NSW have changed as a result of the field trip. Here, we present excerpts from these essays and graziers' views of their interactions with the students which demonstrate the success of this interactive model of teaching and learning in broadening knowledge and dispelling misconceptions. At the end of the trip students, the likely agency policy-makers of tomorrow, have a deeper understanding of those challenges, and the graziers have had their voices heard. We believe the end result is a more sustainable future for both the land and its people.

ON DROUGHT:

... [lack of] soil moisture for pasture, rather than water to drink, was really brought home by the number of dead animals at water points. Now I understand what is meant by 'pasture drought'...Animals don't die of thirst – they starve to death ... (Gabrielle van Willigen, 2003)

...some government policies such as Exceptional Circumstances do not reward or assist those farmers that manage properties effectively...environmentally sustainable management practices are not promoted ... (Rachel Crewe, 2003)

ON THE ECONOMIC REALITIES OF RANGELANDS GRAZING:

[Given] considerable capital expenditure, low land values, and persistent negative returns from sheep grazing, the economic merit of grazing is questionable ... (Kim Whillock, 2003, accountant and daughter of a grazier!).

ON THE MANY AND VARIED ROLES OF WOMEN IN THE RANGELANDS:

Annette Turner from *Polpah*, near White Cliffs, NSW, explaining the challenges of raising three children whilst running a grazing property

... wife, mother, teacher, emergency nurse, stock hand, accountant, small business manager, family counsellor, industry spokesperson, community leader, pig shooter, sheep butcher, horticulturalist, social secretary ... (Deb Young, 2003)

Aside from [their role in] the family unit, ... women like Annette Turner are the backbone of community welfare ... she inspired all the students with her involvement in employment schemes for local residents of White Cliffs ... (Rachel, Crewe, 2003)

SO, WHY DO THEY (THE GRAZIERS) DO IT (THE GRAZING)??

... it's part of my culture ... (Barry Turner, *Polpah*)

... beautiful country, nice people, being ultimately responsible for how the land is managed ... (Mark Etheridge, *Kalyanka*)

AND WHAT DO THE GRAZIERS GET OUT OF THIS TIME SPENT WITH ENVIRONMENTAL MANAGEMENT STUDENTS?

"I ... have an obligation to help people understand this country and how it is being managed. By discussing our approaches, hopefully we open the way to more appropriate management ... (Mark Etheridge, *Kalyanka*)

Our three children ... need[ed] to have a balanced view [of environmental issues]. They needed to rub shoulders with people who had ... a passion as far as environmental issues go ... [and] it has opened the door to a network of professionals always ready to answer questions, offer advice, and support us in our efforts ... (Annette Turner, *Polpah*)

We actually look forward to sharing our knowledge with the students. In return we have become very much more aware of our surrounding landscape and, where possible, have made changes to protect it. Through this connection we have become even more convinced that by giving and taking on both sides, productive grazing and environmental conservation can co-exist ... (Virginia Angell, *Mt Jack*)

IS THIS A SUCCESSFUL MODEL FOR TEACHING AND LEARNING ABOUT THE RANGELANDS?

If the responses of both the students and the graziers are any indication, then the answer is a resounding 'Yes!' Our current students consistently give the unit and its teaching very high ratings, and tell us (and other students) how much they enjoyed the unit and how much they learnt. Our graduates report that they are applying in the workplace what they learnt about the intricate social, political, economic and historical linkages of NRM in the rangelands. Although it can be inconvenient to them, the graziers keep inviting us back. They encourage us and our colleagues to do research on their properties, and through them, other graziers have asked us to visit their properties. And they have agreed to us talking about them at this conference of the Australian Rangelands Society: no better endorsement than that!

FIELD GUIDE TO THE PLANTS OF OUTBACK SOUTH AUSTRALIA

Frank Kutsche and Brendan Lay

Pastoral Program, SA Department of Water, Land and Biodiversity Conservation,
GPO Box 2834, Adelaide, SA 5001

INTRODUCTION

The Pastoral Program has recently produced a field guide of native and introduced plants that occur within the rangelands region of South Australia. The guide is of a convenient size, durability, and affordability to satisfy a large range of end-users. A partnership between the Soil Boards of the rangelands of South Australia, the Pastoral Program – Department of Water, Land and Biodiversity Conservation (DWLBC), and the Plant Biodiversity Centre - Department of Environment and Heritage (DEH), with major funding from the Natural Heritage Trust, has enabled this full-colour quality field guide to come to fruition. As part of collaboration between State government departments the Design Publishing Unit (DEH) has carried out the artwork and layout.

The pastoral rangelands region, or "Outback" as it is often referred to, is a vast, unique and valuable asset to the South Australian community. It constitutes more than 80% of the State's land area, a large area north and west of Port Augusta. Pastoral leases grazing sheep and cattle cover more than 50% of this area, with the remainder under Conservation Reserves, Mining and Aboriginal Land use.

There has been an increasing interest in this region as a tourist destination, brought about by such initiatives as "The Year of the Outback", and increased accessibility with Public Access Routes instigated by the Pastoral Board of SA. Many of the visitors to this area take a large interest in what they are seeing, whether it is the geology, the fauna or the flora. In addition to tourists, other major interest groups for this book are pastoralists, scientific communities and the education community. Information contained within can aid in making management decisions. The book is also a valuable asset for interstate people due to the wealth of information contained within.

RATIONALE AND DESIGN

The design brief aimed to address several questions that had been asked in the past regarding plant books for this State. Have you ever had a plant in your hand when you were working in the Outback, or on holidays but had no handy reference book? How many times have you thought those reference books are just too big to carry around, costly to buy or too easily damaged? Have you ever wanted a field guide that was specific to the Outback region of South Australia?

To cater for all interest groups the language used in the guide is simple and follows a similar format to the well-respected but large-sized *Plants of Western New South Wales* (Cunningham *et al.* 1992). This book has until now formed the main basis for plant identification for people in the region but contains many plants that do not occur in SA. Other books use scientific language necessitating constant use of a glossary and generally cater for specific audiences. The field guide addresses the issues of convenient size (glove-box sized), simple language, cost and plants that occur in this State.

A total of 356 species are fully described and illustrated with high quality photos including close-ups of distinguishing features and the plants in their natural environments. The featured plants are a combination of the most common plants obtained from the Pastoral Program's extensive database as well as less-common species that would hold special interest. Many pastoralists requested the inclusion of weed species so these are highlighted. Rare and endangered species are featured with their current status provided by the Department of Environment and Heritage (DEH). The field guide contains the most up-to-date location map information and scientific names provided by the Plant Biodiversity Centre of the South Australia DEH.

In addition to the simple language used throughout the guide a glossary provides further assistance with plant identification. This particular glossary is unique in that it includes close-up photos of the plant's distinguishing features rather than diagrams, to aid in recognition and familiarisation of features in plant identification in a "real" sense. This unique feature would make a valuable addition to other field guides.

The field guide is made from durable materials for work in the field such as a flexible plastic cover and "varnished" ink on the internal pages. A wealth of information is contained despite the relatively small size. This includes the plants' lifeforms, such as trees, shrubs, forbs, grasses and miscellaneous, including lilies, mistletoes and sedges.

Quick reference guides provide details on each plant's size, flowering time and how common it is, based on a three-tier system of common, locally common and uncommon. Leaves are described with common shapes for easy recognition, for example spearhead-shaped.

Scientific names form the main titles due to the regional variance in common names. Variations, subspecies and form taxon are given where applicable. The most widespread common name and lesser regional common names are also included. Textual information includes descriptions of plant shapes, bark, and sizes and descriptions of leaves, stems, flowers and fruits. Soils and land types that plants occur in feature also (including quick reference icons). A "comments" section includes information on pastoral use and general interest sourced from pastoralists and similar books such as Cunningham *et al* (1992). Comments on Aboriginal usage are largely sourced from the comprehensive *Bushfires and Bushtucker* (Latz 1996) as well as several smaller regional sources. Location map regions for each plant are based on those shown in the *Flora of South Australia* (Jessop and Toelken 1986) for continuity within the scientific community.
This book is a unique compendium of information to guide the management and conservation of the most widespread and important plants in the rangelands of South Australia. It builds on the vast amount of information collected during the pastoral lease assessment program of the Pastoral Program in the SA DWLBC, and from scientific study. It has been written by scientific staff of the Program with 53 years combined knowledge in the rangelands region and incorporates the lifetime experience of many of our pastoral land managers in the region. The amount of information and photographs results in this book being a "must-have" for residents and serious visitors to the region.

SALES AND FEEDBACK

For more information on retail and wholesale sales, and to provide feedback, contact the Pastoral Program in the South Australian Department of Water, Land and Biodiversity Conservation on freecall 1800 678 447.

REFERENCES

Jessop, J.P. and Toelken, H.R. (eds) (1986). *Flora of South Australia*, 4th Edition. The Flora and Fauna of South Australia Handbooks Committee, South Australian Government Printing Division, Adelaide.

Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. and Leigh, J.H. (1992). *Plants of Western New South Wales*. Inkata Press, Melbourne, Sydney.

Latz, P. (1996). *Bushfires and Bushtucker I.* IAD Press, Alice Springs.

CHANGING DIRECTIONS IN MANAGING WESTERN AUSTRALIA'S PASTORAL LAND

B.A. Lloyd

Department for Planning and Infrastructure, PO Box 1575, Midland, WA 6936.

In Western Australia there are approximately 474 pastoral stations covering about 90 million hectares or 36% of the State. Changing community expectations as to how land is managed, along with globalisation and triple bottom line reporting will continue to shape the administrative environment that oversees the pastoral industry. The global community will also be increasingly scrutinising both the quality of product and the processes that produce it, which will ultimately determine the markets for rangeland products. Simply producing volume is no longer sufficient to sustain the pastoral industry.

PASTORAL LAND ADMINISTRATION

The Pastoral Lands Board (PLB) has the responsibility to administer Western Australia's pastoral leases. The adoption of the current *Land Administration Act 1997* saw an expansion of powers and functions of the PLB, with a specific emphasis on the environment. In particular, the PLB is charged with ensuring 'that pastoral leases are managed on an ecologically sustainable basis'. The PLB now also specifically has the ability to:

- Develop policies to prevent the degradation of the rangelands;
- Develop policies to rehabilitate degraded or eroded rangelands and to restore their pastoral potential;
- Establish and evaluate a system of pastoral land monitoring sites; and
- Monitor the numbers and the effect of stock and feral animals on pastoral land.

The PLB's broader focus is reflected in its expanded membership from five to eight, with not only three pastoral representatives, but also a member with expertise in flora, fauna and/or conservation management and an Aboriginal member with pastoral experience.

The PLB's work is carried out by a group of six officers of the Pastoral Land Management section of the Department for Planning and Infrastructure (DPI). These officers include a Manager, an Executive Officer and assistant, a Project and Compliance Officer and two administrative staff. The Project and Compliance Officer is a new position which reflects the PLB's commitment to more effective administration of the State's pastoral lands. This officer provides industry intelligence to the PLB, liaises with all levels of pastoral stakeholders and investigates specific land management issues. The considerable lease inspection program is undertaken by the Department of Agriculture through a Memorandum of Understanding.

NEW DIRECTIONS

The challenges of the modern pastoral industry are being met by the new PLB and its increased powers, by taking a broader and longer term vision for the industry and its role in society.

The PLB and its support staff are not only streamlining existing processes, but developing new ones to provide more positive support for pastoralists, in such areas as goat management, diversification options and training for new pastoralists. With its support staff, the PLB will also quickly and effectively deal with any situations resulting from irresponsible management practices.

The PLB is also well positioned to make strong contributions to future Government decisions on issues such as tenure, access to pastoral leases and land exclusions when all pastoral leases are renewed in 2015. The PLB and its support staff played a key role in a recent series of forums that were convened by the Minister for Planning and Infrastructure. Key issues affecting the State's pastoral industry were investigated and reported on, these being sustainability, access, Aboriginal access and living areas, alternative models for land tenure and economic monitoring requirements. A response from Government is due later in 2004.

INITIATIVES

The PLB and its DPI support staff are continuing to develop both strategic and operational initiatives to support the sustainable management of pastoral leases:

- The PLB's new webpage (www.dpi.wa.gov.au/pastoral) provides pastoralists with positive support and relevant information from which to make informed management decisions. The website encompasses information on the 'triple bottom line' of environmental, economic and social sustainability.
- Diversification allows pastoralists to maintain their core pastoral businesses by stabilising cash flow and spreading risk in times of fluctuating commodity prices or during prolonged adverse climatic events, such as drought. The PLB has streamlined its administration processes that provide for more effective referrals for Applications for Diversification Permits to all relevant stakeholders from both government and non Government (such as Native Title claimants), as well as fast-tracking applications from new lessees undertaking diversification activities as done by the previous pastoralist.
- The PLB has improved its Management Plan Template to assist pastoralists in the development of focussed, strategic and timebound station plans to facilitate consequent on-ground improvements. These plans are also often required by the PLB in response to issues raised in lease inspection reports and when a new lessee takes over a station.
- Mining companies that lease stations have some unique issues in conducting two very different enterprises on the lease. The PLB support staff are working with key mining companies in establishing a Mining Industry Reference Group. This group would develop and facilitate the adoption of Best Management Practices on these pastoral leases.
- The PLB supports increasing the management capacity of new pastoral lessees and accredited training for the next generation of the pastoral workforce. Support staff are actively involved with other stakeholders in the development of a pilot training program to enhance the management capacity of Aboriginal pastoral lessees.
- Unauthorised access is an ongoing issue on pastoral leases. There are plans to produce a high quality brochure to inform the increasingly mobile public about responsibilities in accessing pastoral lands. The PLB support staff were also actively involved in the removal of one unauthorised camp on a coastal pastoral lease.
- Irresponsible management by a few undermines the industry's credibility and market confidence. The PLB and its support staff are concentrating efforts on quickly and effectively dealing with individuals that show little regard for their responsibilities as pastoralists.

CONCLUSION

These initiatives emphasise the new direction of the Pastoral Lands Board and will help ensure Western Australia's pastoral industry meets the inevitable industry challenges and expectations of society with a positive and proactive response. The community will ultimately demand greater stewardship and accountability in managing pastoral lands. The PLB's work towards sustainable pastoral leases will lead to long-term sustainability for these regions, with positive outcomes for pastoralists, the industry, the rangelands and the State.

BARKLY RANGELAND MANAGEMENT COURSE

Chris Materne [1], Pam Allsop [2] and Alaric Fisher [3]

Department of Business, Industries & Resource Development
[1] PO Box 8760, Alice Springs, NT 0871
[2] PO Box 159, Tennant Creek, NT 0861
[3] Department of Infrastructure, Planning & Environment, PO BOX 496, Palmerston, NT 0831

The Barkly Rangeland Management Course was initially developed in 1999 through Landcare support and Natural Heritage Trust (NHT) funding. It was developed in response to requests from landholders for information on sustainable land management in respect to beef production.

The course is an education package comprising a series of modules that are available to employees on all cattle stations in the Barkly Region. The objective of the course is to improve participants' understanding of native pasture dynamics, to train them in plant identification and basic monitoring techniques, and to stimulate their interest in using pasture monitoring to make sustainable land management decisions.

Participants are given a combination of theory and practical sessions over the duration of the course. Presenters are from the Departments of Business, Industries and Resource Development and Infrastructure, Planning and Environment. The information presented is based on local research and experience, and covers a range of topics, including plant identification principles and pasture dynamics, fire management, weed and poisonous plant management and beef cattle nutritional requirements and associated supplementation strategies.

The course is continually being developed and through an initiative of the Barkly Landcare and Conservation Association and NHT Envirofund has enabled a biodiversity management component to be added to the course in 2003.

LITTER FALL AND NUTRIENT INPUT BY THREE TREE SPECIES IN A SEMI-ARID TROPICAL SAVANNA

Peter O'Reagain, John Bushell & Chris Holloway

Department of Primary Industries & Fisheries, PO Box 976, Charters Towers, 4820.

INTRODUCTION

Studies in temperate and sub-tropical Australia indicate that trees play a major role in nutrient cycling e.g. Attiwell *et al.* (1978) and hence are important in maintaining system productivity and sustainability (Keith 1997). Trees access nutrients in deep soil layers and subsequently enrich the surface soil through litter fall and deposition, increasing nutrient availability to shallower rooted life forms like grasses. Leaf litter also increases soil faunal activity, further improving soil condition via increased hydraulic conductivity, aeration and nutrient cycling.

Trees are also likely to play a key role in nutrient cycling in the northern savannas. However, with the exception of McIvor (2001), this role has yet to be quantified. This is of concern given the dystrophic nature of these savannas and the ongoing controversy regarding broad-scale tree clearing. The present study was therefore initiated to quantify litter and nutrient inputs from three important tree species that occur on relatively nutrient poor soils in these savannas.

METHODOLOGY

The study was conducted at the 'Wambiana' grazing trial, near Charters Towers, North Queensland. Mean annual rainfall is 650 mm with a C.V. of 38 %. Tree species selected were silver leaf ironbark (*Eucalyptus melanophloia),* Reid river box (*E. brownii*) and brigalow (*Acacia harpophylla)*, which occur as local dominants on yellow kandosols, brown sodosols and cracking clays respectively. Leaf and fine twig litter were collected monthly using conical shade cloth traps (i.d. 70 cm) placed under the canopies of 13 - 14 individuals of each species. Selected trees varied in size and canopy density but covered the full range of typical adult to sub-adult trees in that area. For each species, groups of three to five litter traps were grouped into replicates. These replicates were separated by distances of between 200 to 1500 m. Samples were dried for 48 hours at 60° C, weighed and bulked by replicate for nutrient analysis. Litter weights are presented for the period November 2001 to March 2004 but nutrient data are only available for the first year of litter collection. Data were analysed via a repeated measures ANOVA on GENSTAT.

RESULTS AND DISCUSSION

There was no clear seasonal pattern of litter fall in any of the tree species although there was a trend for reduced litter fall in July-August and a tendency for increased litter fall during the summer months (Fig. 1). However, this trend was not as marked as that reported by McIvor (2001) or Burrows and Burrows (1992).

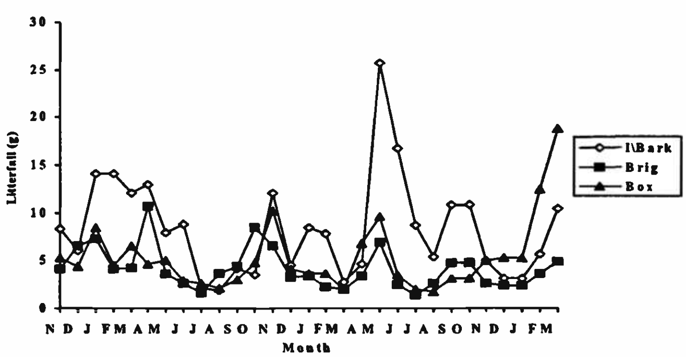


Fig 1: Monthly litter fall (g/DM/trap) for three savanna tree species at the Wambiana grazing trial. (Brig. = brigalow, I\Bark = ironbark)

There were however, marked species differences in average litter fall with ironbarks producing nearly twice as much leaf litter (8.5 g/month/trap) as box and brigalow (*c.* 4.5 g/month/trap). When extrapolated upwards to an area basis using canopy cover data for the site, total litter input varied between 500 and 780 kg/ha per annum depending on the species present and canopy cover. These figures are similar to those reported by (McIvor 2001) for a *E. drepanophylla* community growing on more fertile grano-diorite soils east of the study site.

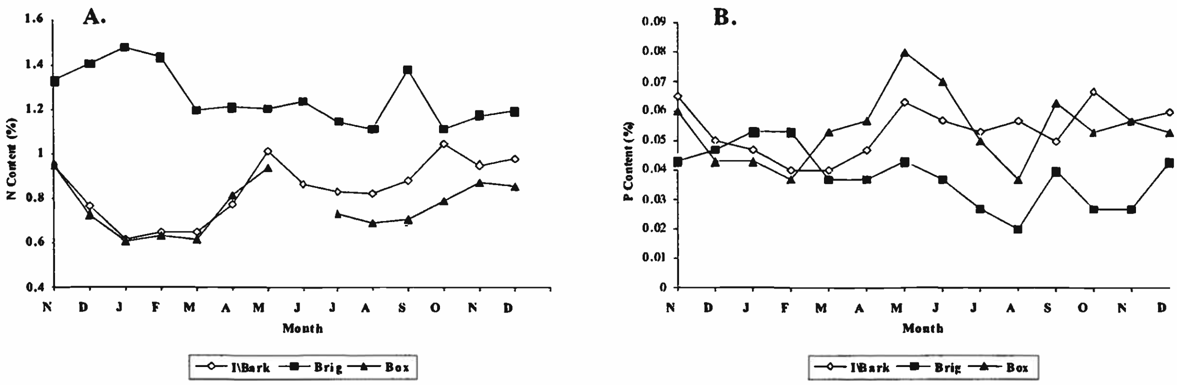


Fig 2: Change in N content (A) and P content (B) of litter fall from three savanna tree species at the Wambiana grazing trial. (Brig. = brigalow, I\Bark = ironbark)

There were marked differences in the nutrient content of litter collected from the three species (Fig. 2). Brigalow litter had a higher N content (mean: 1.25% N), on average, than litter from the two Eucalypt species (mean: 0.8% N): this difference was significant ($p<0.05$) in ten out of the twelve months compared. The relatively high N level of brigalow litter is logical given the ability of this species to form mutualistic relationships with N fixing bacteria. In contrast, ironbark and box litter (mean: 0.054% P) tended to have a higher P content than brigalow litter (0.038% P), although these differences were only significant ($p<0.05$) in six out of the twelve months compared. This trend is surprising given that brigalow grows on heavy clay soils with a relatively greater cation exchange capacity and P content than the relatively infertile kandosols and sodosols commonly occupied by the ironbark and box respectively.

Total nutrient input per area via leaf litter fall varied between communities depending upon the tree species involved. Overall total N input was lowest for box (5.0 kg/ha/yr), moderate for ironbark (6.0 kg/ha/yr) and highest for brigalow (8.7 kg/ha/yr) communities. Conversely, predicted P inputs were highest for ironbark (0.38 kg/ha/yr) followed by box (0.30 kg/ha/yr) and brigalow (0.27 kg/ha/yr) communities. These results indicate that trees are an important source of nutrients in these low fertility systems and are likely to have a major impact upon ecosystem processes in such communities.

ACKNOWLEDGEMENTS

We are grateful to the Lyons family 'Wambiana' for the use of the trial site. We thank Angela Reid for data analyses and Peter Allen for field assistance. This work was funded by the CRC for Tropical Savannas Management.

REFERENCES

Attiwell P.M., Guthrie G.B. & Leuning R. (1978). Nutrient cycling in a *Eucalyptus obliqua* (L'Herit.) forest. 1. Litter production and nutrient return. *Aust. J. Bot.* 26: 79-91.

Burrows D.M & Burrows W.H. (1992). Seed production and litter fall in some Eucalypt communities in Central Queensland. *Aust. J. Bot.* 40: 389-403.

Keith H. (1997). Nutrient cycling in eucalypt ecosystems. In: *Eucalypt Ecology: Individuals to ecosystems*'. Eds. Williams J.E. & Woinarski J.C.Z. Cambridge University Press, Cambridge.

McIvor J.G. (2001). Litterfall from trees in semi-arid woodlands of north-east Queensland. *Austral Ecol.* 26: 150-155.

HOW UNIQUE IS THE CHANNEL COUNTRY?

D.G. Phelps

Department of Primary Industries & Fisheries, PO Box 519, Longreach Qld 4730

INTRODUCTION

Roberts (1996) cited the pastures of the Channel Country as the equal of any of the great flooded systems of the world – the Okavango Delta, the flooded Pampas and the Pantanal. However, anyone who has lived or worked in the Channel Country states that it is unique in the world. Is this really true? This paper compares and contrasts some features and issues of the Channel Country with areas identified by Roberts (1996) and with Red Creek, Wyoming, USA due to its similar hydrology (Schumann 1989). A Samuel and Eileen Gluyas Churchill Fellowship study tour (Phelps 2003a) is drawn upon in this précis.

THE CHANNEL COUNTRY, AUSTRALIA

The floodplains of the Channel Country comprise approximately 54,000 sq km of the Georgina and Diamantina Rivers and of Cooper Creek within arid inland Queensland and South Australia. The term 'Channel Country' was coined from the broad expanses of multiply-braided (anastomosing) channels which can flood out across plains up to 70 km in width. Native pasture growth following these irregular flood events can exceed 5,000 kg/ha of dry matter, with associated cattle liveweight gains similar to feedlot rates (Phelps 2003b). The area has been used primarily for cattle production by corporate and family operations on leasehold land since European settlement in the 1880s. A substantial proportion of cattle production is now certified organic. Areas of cropping in lakes have been attempted but generally failed to gain support. One attempt to establish an irrigation industry on Cooper Creek in the mid 1990s was stopped largely through local concerns over water extraction and chemical usage. Tourism and conservation have increased over the last 10-20 years. Perhaps the largest threat to natural integrity of the Channel Country is from altered water flows from infrastructure development at key locations, or from changes to overland flow rates e.g. large, fast, floods could down cut channels or accelerate sedimentation levels. Regionally based natural resource management plans (for both water and land) are either current or being finalised.

THE OKAVANGO DELTA, BOTSWANA

The Okavango Delta consists of multiple swamps, flood-outs and channels overlaying deep sands of the Kalahari Basin in northern, arid, Botswana. It is approximately 28,000 sq km in area (Ringrose *et al.* 1988) and is at similar latitude to Camooweal on the upper reaches of the Georgina River. Most of the water originates in Angola and flows into the Okavango Delta via the Okavango, Cubango and Cuito Rivers. Cattle grazing and limited cropping on communal land has dominated land use around the edges of the Okavango, but the prevalence of sleeping sickness carried by the Tze Tze fly has reduced human occupation within the delta until recent times. Tourism, hunting, fishing, conservation and the harvesting of native plants (e.g. palm leaves for basket weaving) are becoming large industries within the Okavango Delta, placing pressures on the natural resource base. Regional and international planning is now addressing these pressures. Perhaps the largest potential threat is reduction in water access as Angola embarks on large-scale irrigation. Changes to the structure and distribution of vegetation is also important to regulating flows, from slowing the passage of water over land in the upper catchments to filtering sediments and potentially diverting flows within streams themselves.

THE SOUTHERN PANTANAL, BRAZIL

The Pantanal is formed within the catchment of the Paraguay River, which drains into large areas of swamp and floodplain before continuing into the country of Paraguay and finally into the Paraná River in Argentina and the Atlantic. The southern Pantanal is sub-tropical, located at a similar latitude to

Camooweal. The Brazilian section of the Pantanal is approximately 130,000 sq km in size, stretching from Poconé in the north to Miranda in the south and hugging the Bolivian border to the west. The major land-use is cattle grazing on freehold land, although clearing for cropping and introduced pastures is occurring on higher ground, with cattle production becoming integrated to include feed lotting. Research is focusing more towards sustainable natural resource management.

THE FLOODED PAMPAS, ARGENTINA

The flooded pampas stretches inland for some 600 km from the central eastern seaboard of Argentina, occupying up to 550,000 sq km. It is mostly temperate, with annual flooding due to poorly defined river systems. The major land-use is cattle grazing on freehold land, with introduced grass, legume and tree species (such as *Lotus* spp. and *Eucalyptus* spp.) greatly increasing productivity over native tussock grass pastures. Cropping on the higher areas is becoming prevalent, reducing the area available for cattle grazing during the flooded months. There is also a push for increased productivity within the Pampas, with no resource management planning currently underway.

RED CREEK, WYOMING USA

Red Creek is a small (approximately 9 sq km) anastomosing stream within the Red Desert area of the Rocky Mountains inter-mountain basin. It is an endoreic (internally draining) system within high (cold) desert that floods annually to promote perennial shrubs on small floodplain areas adjacent to the main channel and anabranches. It is public land managed by the Bureau of Land Management for sheep grazing and hunting access. Mining for gas is becoming prevalent, and is likely to increase. Unlike many streams within North America, Red Creek is intact, with little evidence of down cutting. Many other flooded systems in the USA are now dysfunctional, with streambeds up to tens of meters lower than their original levels. Much of the down cutting is reported to have resulted from changed rates of overland flow, as well as grazing removing stabilising vegetation from the banks and within stream benches. In many cases, former naturally flooded meadows now have no possibility of streams flooding out again, floodplains having formed on shelves within the defined streambed instead.

CONCLUSIONS

The floodplains of the Channel Country have many similar resource management issues to other flooded systems of the world, including the potential for water diversion and the interruption to natural flood levels and distributions. The area subject to inundation is not the largest in the world, nor is the level of productivity the highest. However, it is unique in its combination of extensive and fertile clay soil floodplains with intermittent inundation within an arid environment. The desire and the ability for the community of the Channel Country to maintain relatively unaltered natural systems for cattle grazing, resisting both cropping and extensive areas of introduced pasture, also sets the area apart from the other great flooded systems of the world.

REFERENCES

Phelps, D.G. (2003a). The Samuel and Eileen Gluyas Churchill Fellowship to study international floodplain pastures with similarities to the channel country of inland Australia. Report to the Winston Churchill Memorial Trust of Australia.

Phelps, D.G. (2003b). Sustainable Grazing In The Channel Country Floodplains. A Technical Report on Findings Between June 1999 And August 2002. Report to Meat and Livestock Australia.

Ringrose, S., Matheson, W. and Boyle, T. (1988). Differentiation of ecological zones in the Okavango Delta, Botswana by classification and contextural analyses of Landsat MSS data. *Photogrammetric Engineering and Remote Sensing* 54: 601-8.

Roberts, B. (1996). The Value and Dynamics of Native Pastures of the Cooper Creek area (Chpt 4.12). *In* "An Ecological Perspective on Cooper's Creek: Summary Proceedings, Windorah Scientific Workshop". Noonan, D. Adelaide, Australian Conservation Foundation: 1-15.

Schumann, R.R. (1989). Morphology of Red Creek, Wyoming, an arid-region anastomosing channel system. *Earth Surface Processes and Landforms* 14: 277-88.

FENCES, LAND MANAGEMENT, HISTORIC HERITAGE AND THE FUTURE OF RANGELANDS

John Pickard

Department of Physical Geography, Macquarie University, NSW 2019 (jpickard@els.mq.edu.au)

Although fences are ubiquitous in Australian landscapes, they are neglected objects of study. Fences are the basic management tools used to separate property, livestock and crops, and to facilitate management. Consequently, the geographic pattern, age and condition of fences can provide valuable clues about the management history of a region, and form a basis for future management.

In this paper I describe how fences allow us to understand past management, and how fences are vital tools in understanding the impact of landscape changes (erosion and deposition). I briefly consider the problems of conserving fences as important relics of European historic heritage in semi-arid rangelands. Finally, I discuss how fences provide valuable information for the future management of semi-arid rangelands.

FENCES REVEAL PAST MANAGEMENT

The two basic keys to stock management in semi-arid rangelands are fences and watering points. Consequently, both can reveal much about past management. In the late 1890s, Peter Waite, then managing director of The Momba Pastoral Co., introduced a revolutionary system of sheep management. He erected hundreds of kilometres of "lightning" fences on the properties run by the Elder Smith companies in NSW and SA. The pattern of derelict fences from this period record this management innovation. Similarly, derelict sheep fences in the southern Northern Territory provide mute testimony to failed attempts to run sheep without effective dingo control.

FENCES AND LANDSCAPE CHANGE

Fences were both an agent of landscape change, and a way of recognising and quantifying changes in semi-arid landscapes. Before the widespread adoption of steel posts and droppers in fences, all posts and droppers were wood. Almost invariably, the timber was obtained locally off the property, close to the line of the fence. Using annotations on survey plans showing details of fences (panel lengths, etc), it is possible to calculate the numbers of posts used to fence properties. Panels ranged from as wide as 30' to as close as 10', requiring from 110 to 300 posts / km. Moderate-sized properties in the Western Division of NSW required at least 14,000 posts and 3,000 droppers. Extrapolating to the Western Division as a whole, and assuming similar fences, then perhaps 20 million posts were required. As the favoured species were usually Mulga and Gidgee, where only one or perhaps two posts could be obtained per tree, this means that a total of 10-20 million trees was felled solely for fencing.

The introduction of domestic stock to the rangelands very quickly initiated a major episode of surface disturbance, followed by massive erosion. What is less commonly understood is that this eroded material does not simply disappear, it is mostly deposited relatively close nearby. Near White Cliffs, many kilometres of partially buried fences testify to the deposition of sediment eroded from higher in catchments. Knowing the dates of the fences (from old plans) it is possible to calculate overall rates of deposition. These rates are not particularly helpful, as a decade of monitoring reveals that most sedimentation occurs after single isolated intense rainfall. Similar episodes of rapid gully expansion have been recorded at Fowlers Gap Arid Zone Research Station by Fanning.

My field observations during an Australia-wide survey of fences suggest that fence burial is widespread. Thus there is a means to more closely quantify the rates of deposition (and perhaps, erosion) that have taken place since the fences were constructed. In some locations, multiple fences of different ages allow the rates to be partitioned by decades. If such data were linked to historical stocking rates, and rainfall, then we would be better able to understand the magnitude and rates of changes that have occurred in the landscape.

FENCES AS EUROPEAN HISTORIC HERITAGE

Heritage legislation in most states defines historic heritage as non-Aboriginal material over 50 years old. Whether or not a particular object (e.g. fence) is "significant heritage" requires an assessment using the procedures of the Burra Charter. Given the sheer number of old fences, there is no doubt that most are not particularly significant, but all contain important information on European settlement history.

Close study of fences near White Cliffs shows major changes in fence technology used since the first fences were built in the 1870s. All components have changed: wire from 8G iron to 10G steel to 12G high tensile, posts from wood to various steel sections to the now ubiquitous star post, droppers from local wood to bent sheet steel to modern steel. Also, the structure of the fences has changed to make optimal use of the improved technology: both strains and panels are now longer, and use different combinations of plain and barbed wire. Consequently, old fences record all of these technological changes. The structures also record significant information on legislation, investment, labour, and past aspirations. These are relevant to better understanding landscape changes that followed European pastoralism in the rangelands.

Many pastoralists remove old fences before building a newer replacement, or scavenge the old wood posts for firewood. Many fences are left *in situ*, deteriorating into a tangled mess of broken wires and drunken posts. The decision is entirely up to the landholder. But few landholders recognise the historic heritage value of their fences, and others (with no real cause) fear the intrusion of government-imposed heritage preservation orders. A middle road is possible where landholders are aware of the importance of a particular fence, and while not actively conserving it, at least do not destroy it. Many pastoralists highly value the history of their properties, especially when the family has lived there for several generations. When the history of individual fences is explained, I have always received positive responses from pastoralists.

FENCES HELPING THE FUTURE OF SEMI-ARID RANGELANDS

Recent research on climate changes suggests that Australia is now in the first few years of a 40-year long period of below average rainfall. This poses major problems for both land managers and agencies involved in the rangelands. The last time Australia experienced such a prolonged period of below average rainfall was from about 1910 to about 1947. There are no managers alive today with first-hand experience of managing under such conditions. Indeed, all have only worked in the historically higher rainfall period since the end of World War 2. Historically, this has also been the period of excellent prices. Consequently, managers face the bleak prospect of a return to conditions before World War 2: poor prices (and getting worse), low rainfall, long droughts.

The cause for concern is that too many pastoralists, agency personnel and politicians regard the present conditions (and condition of the rangeland) as "normal" and stable. Even a cursory look at the field evidence contained in fences shows that this is a dangerous delusion. It is a delusion because it is incorrect, and pastoralists and politicians have still not accepted the findings of the Royal Commission of 1901 that drought is the norm. It is dangerous because current management and policies are predicated on flawed memories of historically higher rainfall, and the consequent improvement in landscape condition. But, given that the landscape is currently demonstrably unstable, and degradation is still occurring, then the effect of continuing with current management into decades of lower rainfall will be both environmentally and socially catastrophic.

The record of landscape change contained in fences is quantitative, can be related to individual decades, and is a key approach to better understanding what happened pre-World War 2. Without this vital information, we are doomed to repeat the problems of the past.

RELATIVE PALATABILITY OF SELECTED PLANTS IN THE SHRUBLANDS OF WESTERN AUSTRALIA

Peter J. Russell [1*] *and Wayne Fletcher* [2]

[1] Centre for Management of Arid Environments (CMAE), Curtin University of Technology, Locked Bag 22, Kalgoorlie WA 6433. E-mail: p.russell@cmae.curtin.edu.au
* PhD student supervisors: Drs Brien (Ben) Norton and Ian Watson
[2] Department of Agriculture, PO Box 483, Northam WA 6401. E-mail: wfletcher@agric.wa.gov.au

ABSTRACT

This report outlines the methods and results of a survey of experienced rangeland practitioners undertaken in 2003, regarding the relative palatability of a number of perennial plants in the shrublands (southern rangelands) of Western Australia. Results are presented as a chart listing the 47 surveyed plants in order of relative palatability and the palatability range of each, as perceived by the practitioners. Based on mean palatability rank, the plants 'fell' naturally into five palatability classes, denoted "very high", "high", "moderate", "low" and "very low". The two most palatable plants are *Maireana platycarpa* (shy bluebush) and *M. convexa* (mulga bluebush), and the two least palatable plants are *Eremophila fraseri* (turpentine bush) and *E. crenulata* (waxy-leaf poverty bush). Many plants display narrow palatability ranges (1 or 2 classes) but most show a much broader range; the plant with the broadest range (from "very high" to "very low") is *Maireana amoena* (brittle bluebush). The survey was undertaken to test whether more definitive palatability information was contained 'within practitioner heads' than was presently available in published sources. The results, we believe, are more definitive than existing literature, providing a powerful distillation of many collective years of rangeland experience and wisdom, summarised in a concise format, easily assimilated by people of varying experience.

INTRODUCTION

Despite its importance in understanding the impact of herbivores on rangeland landscapes, there is a paucity of concise published information on the palatability of plants occurring in the shrublands of Western Australia, apart from the general information provided in Mitchell and Wilcox (1994). In order to, at least partly, redress this shortcoming, we chose to undertake a survey of experienced rangeland scientists in 2003, with the hope of either 'extracting' better palatability information from 'within their heads' or perhaps unearthing unpublished or obscure sources. The term palatability is used here to mean the general acceptability of a plant to a herbivore, and Vesk and Westoby (2001) clearly argue that palatability is relative, not absolute.

SURVEY AIM AND METHODS

The aim of this exercise was to produce a list of plants showing their palatability relative to each other and the palatability range of each, based on the accumulated field wisdom of experienced rangeland practitioners. Given a hypothetical grazing scenario, 17 practitioners numerically ranked a list of 47 perennial plants from most palatable (rank 1) to least palatable (rank 47). The plants, all described in Mitchell and Wilcox (1994), were selected such that each has a reasonably broad distribution, although not necessarily throughout the entire shrublands, and is reasonably common within its range. Only perennial shrubs and trees were included and the list was limited to less than 50 plants to reduce ranking difficulty. Since the survey was only concerned with palatability, rather than other related aspects such as plant response to grazing, utilization etc, the practitioners were also asked to moderate confounding influences as much as possible. The hypothetical grazing scenario consisted of a very large paddock with all listed plants present at typical densities and having just experienced a run of fair seasons. This paddock was subject to continuously increasing grazing pressure from mixed, managed and unmanaged herbivores, e.g. sheep, goats, and kangaroos.

Analysis was based on rank frequencies and means. Rank counts for each of the 47 plants were graphed against rank to produce a histogram plot, obvious outliers deleted (8% of all counts) and mean palatability rank calculated for each plant. From a plot of mean ranks, ordered from lowest to highest, against rank, five distinct palatability classes were recognised, and were given the names "very high", "high", "moderate", "low", and "very low". A total of 787 counts were used, with individual plants having between 12 and 19 counts.

SURVEY RESULTS

Results of the survey are presented as a chart (see poster in conference display area and also The Australian Rangeland Society website at http://www.austrangesoc.com.au) (Russell and Fletcher, 2003) showing each of the perennial plants:

- Listed in order of mean palatability (relative palatability),
- Palatability range of each, and
- Relative palatability classes.

The two most palatable plants are *Maireana platycarpa* (shy bluebush) and *M. convexa* (mulga bluebush), reinforcing the widely held view that they are highly desirable. The two least palatable plants are *Eremophila fraseri* (turpentine bush) and *E. crenulata* (waxy-leaf poverty bush). Many plants display narrow palatability ranges (1 or 2 classes) but most show a much broader range; the plant with the broadest range (from "very high" to "very low") is *Maireana amoena* (brittle bluebush). Explanation for the broad ranges, particularly for the chenopods, probably lies in confounding effects such as stock water quality and quantity, and variations in plant specific characteristics. It is also possible that practitioner uncertainty, through incomplete knowledge of some species, contributed to the palatability 'spread'.

Considering the palatability range of particular genera, both *Eremophila* and *Maireana* show very broad ranges, from "very high" to "very low" with *Eremophila* spp. tending towards the less palatable end and *Maireana* spp. towards the more palatable end of the spectrum.

CONCLUSIONS

The results, we believe, are more definitive than existing literature (Russell and Fletcher, 2003). By tapping into practitioner perceptions of plant palatability, developed through keen observations of what animals eat, albeit often incidental to their primary field tasks, the chart provides a powerful distillation of many collective years of rangeland experience and wisdom, summarised in a concise format. People working in the field are encouraged to use the chart as a starting point on which to build personal experience, to test the validity of the collective perceptions and hence progress towards more comprehensive understanding of plant utilisation by herbivores and long-term sustainable use of our rangeland landscapes.

ACKNOWLEDGEMENTS
Thanks are due to Ben Norton and Peter-Jon Waddell for constructive comments on earlier drafts.

REFERENCES

Mitchell, A. A. and Wilcox, D. G. (1994). *Arid Shrubland Plants of Western Australia.* University of Western Australia Press.

Russell, P. and Fletcher, W. (2003). Relative palatability of selected perennial plants in the southern rangelands of Western Australia - results of a survey of rangeland practitioners. *Range Management Newsletter*, 03/3, 1-8.

Vesk, P. A. and Westoby, M. (2001). Predicting plant species' responses to grazing. *J. App. Ecology* 38: 897 - 909.

LAND UNIT MAPPING IN THE EAST KIMBERLEY REGION, WESTERN AUSTRALIA

N. Schoknecht [1] *and S. Williams* [2]

[1] Dept. Agriculture WA, Locked Bag 4, Bentley Delivery Centre South Perth, 6983 WA
[2] Dept. Agriculture WA, PO Box 19, Kununurra, 6743 WA

BACKGROUND

The main land resource dataset in the Kimberley is reconnaissance land systems mapping conducted at a scale of 1:250,000 by CSIRO in the 1950s. Land systems delineate areas of recurring patterns of topography, soils and vegetation, however distinctive components of the recurring pattern, known as land units, were not mapped. Subsequent detailed surveys have been restricted to small areas for specific needs (eg. suitability for irrigation). Land management and future land use planning across the Kimberley would benefit from consistent and well-attributed land unit mapping. Land unit mapping has traditionally been time-consuming and expensive, involving intensive fieldwork and air-photo interpretation, then transfer of data to spatial and attribute data sets. A new methodology has been developed to provide a simple way of fast-tracking capture of land unit mapping information whilst incorporating surveyor expertise, thus making it a cost-effective option for the Kimberley.

METHODOLOGY

Three methods were trialed for mapping land units in the Ord Catchment of the East Kimberley.

Disaggregating existing land systems mapping

Newly available digital datasets, especially high-resolution digital elevation models (DEMS) and geology were used to delineate the land units that were described, but not mapped, within the original land system survey. Two key problems were encountered: 1) not all land units that occur within a land system were described and; 2) the land system mapping was spatially inaccurate leading to high levels of mapping impurity. This method was thus abandoned.

Modelling

Our modelling approach used a method developed by CSIRO Land and Water for land resource mapping in the Murray-Darling Basin. This approach relied on a representative set of digital predictor datasets (geology, DEM, etc.) and training data to develop and test the models. This method was unsuccessful in the study area although valuable data were collected through this process and it precipitated the development of a third and successful method.

Hybrid approach combining traditional and new technologies

A new hybrid method was developed using a combination of all digital data (point, polygon and raster) projected into a common geographic space, with expert interpretation to guide the process of defining land units directly on screen. This method was considered superior to other methods as it captured the best of both the digital information available and requisite expert knowledge, and was thus adopted for the land unit mapping process.

The new method fast-tracked some of the traditional steps by using on-screen digitising where all available and relevant digital data were displayed in the same datum and projection. Microstation® SE 98 and Image Analyst© were used in parallel to display and overlay data, and to create linework to delineate land units. Various raster (image) and vector (shape) data sets were switched on or off and overlaid as required. Aerial photographs were used alongside the digital data, and expert interpretation was built into the land unit line-work as it was drawn. This is a novel approach for the region, as these data have never before been compiled into the same digital work-space.

Digital datasets used were: Geology (1:100,000 and 1:250,000), Digital Elevation Model (30m grid – outputs: sunshaded, slope, 10m contours), Landsat 7 TM (bands 321, 542 and 741), vegetation map (1:2,000,000), all available soil, land unit and systems mapping, field data (soil, landscape, geology, vegetation), climatic and vegetation data, air photographs, and other maps. Some derived data sets were created for defining and interpreting different land types; eg. a sunshaded 3D image (sun angle 45° above horizon, from a NE or NW direction) and a 10m contour map were generated from the DEM. Such data were particularly useful for identifying slope and relief, thus delineating rugged, hilly land types. Conversely, low relief plains landscapes were better identified through Landsat scenes, air photos and field information. By carefully selecting and combining various datasets that highlighted different landscapes, land units were more effectively identified and described.

The map is built in parallel with a database (Microsoft® Access 97) in which all land units are coded and defined. The output is a map of land unit polygons, each polygon with an identifying label linked to a database where properties of the polygon (land units) are described.

DISCUSSION

In the past, mapping has been carried out on unrectified air photos using other maps (eg. geology) to assist the process. This approach was slow and had limited accuracy due to the different maps not being aligned into a geo-referenced workspace. The new hybrid technique is estimated to at least double the rate at which landscapes can be mapped when compared with traditional methods. The technique has been successfully trialed by the Natural Resources Assessment Group within the Department of Agriculture WA to up-scale mapping in the agricultural south-west region of WA and thus far, for two pastoral leases in the East Kimberley.

Maintaining original land systems information in the land unit mapping was considered valuable, so the new, more detailed mapping was built into a labelling hierarchy that enabled land systems to be regenerated from the best available mapping. Therefore land units could be grouped (coloured the same) to generate a land systems map for a regional scale picture (refer our poster and Figure 1). This novel method successfully marries new and old datasets and technologies with expert knowledge, to produce a map of higher resolution and accuracy at a significantly lower cost than traditional mapping efforts.

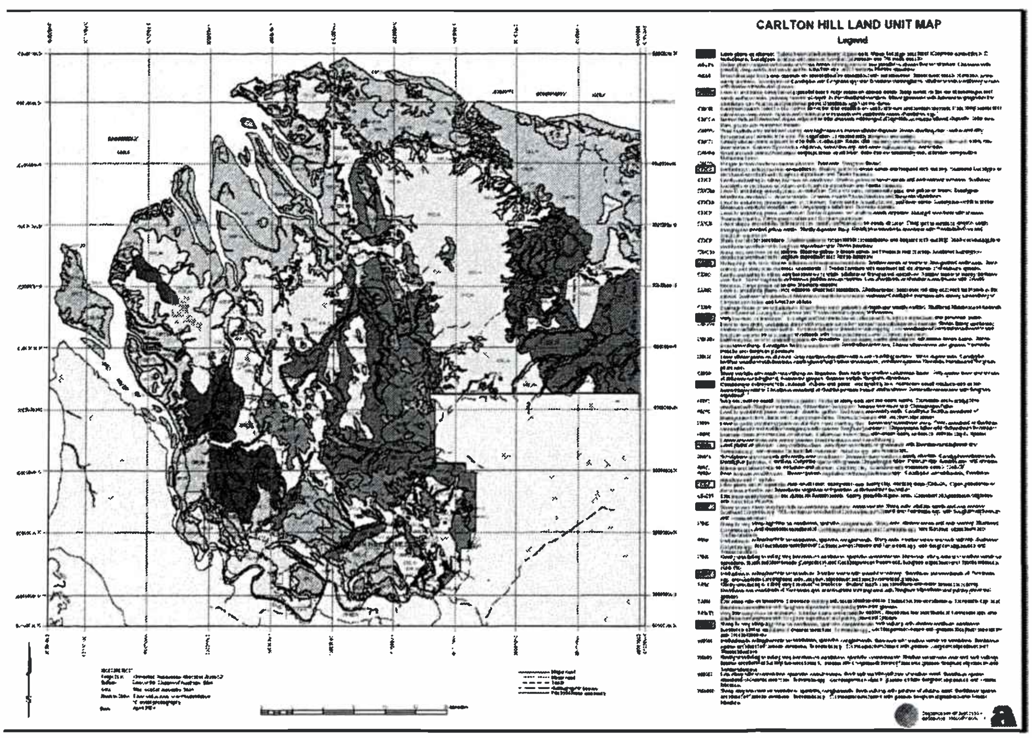


Figure 1: Map of land units (black line work) with units grouped to land systems (coloured), using a new method. The legend is build from a database query that combines the various map unit attributes.

USE OF FAECAL NEAR INFRARED REFLECTANCE SPECTROSCOPY ON RANGELANDS OF THE GREAT DIVIDING RANGE

K.J. Sibson and B. Alchin

University of Queensland, Gatton Qld 4343

BACKGROUND

Beef cattle production has been carried out on the basalt soils – Queensland bluegrass (*Dicanthium sericeum*) areas of the Great Dividing Range in south-east Queensland for over 100 years. However, the native pastures in these areas often do not meet the nutritional requirements of the animals, particularly during the usually dry period through late Autumn-Winter-early Spring.

The relatively new technology of Faecal Near Infrared Reflectance Spectroscopy (FNIRS) was developed to predict various dietary attributes (Coates 2000). The analysis technique is rapid and single samples determine a wide range of attributes, including dietary and faecal nitrogen, dietary digestibility, grass component of the diet and average daily weight gain.

The purpose of this study was two-fold: (1) to investigate the nutritional profile of cattle grazing on native pastures in the late Winter-early Spring, and (2) to assess the efficacy of the standard FNIRS sampling technique.

METHODOLOGY

Pasture and faecal samples were taken from an open grassed paddock on the colluvial slopes on "Glen Rock", 60 km south of Gatton in SE Qld. The 300 ha paddock carried 100 Brahman-cross steers and represented typical grazing pressure for the region.

The pasture and faecal material were sampled on a weekly basis between August and October, 2003. Each faecal sample set consisted of ten separate faecal samples, which were bulked and sub-sampled in the paddock. On two separate occasions, twenty individual faecal samples were taken and analysed to determine their variation using the FNIRS sampling technique.

On each sampling date, five replicates were taken of all the pasture to 2 cm above ground level within a 1 sq m quadrat. Individual species within each sample were separated. The two most dominant pasture species, Queensland bluegrass and wiregrass (*Aristida* spp.) were analysed for nitrogen.

RESULTS AND DISCUSSION

Nutritional profile of cattle

A summary of some of the data is in Table 1. There was a general decline in crude protein from August to October. However, a significant rainfall event in late September resulted in growth of annual forbs and this produced an increase in dietary crude protein (CP).

The efficacy of FNIRS for faecal nitrogen analysis

The correlation between faecal nitrogen as determined by FNIRS and from standard auto analysis was relatively high (R^2=0.82). No NIRS value departed more than 0.35% from the regression line. This indicated its use for this purpose in the rangelands of the Great Dividing Range is appropriate.

Table 1. FNIRS data for Queensland bluegrass pastures on the Great Dividing Range in SE Qld.

Date	Qld Bluegr. Nitrogen (%)	Wire grass Nitrogen (%)	Dietary CP (%)	Faecal Nitrogen (%)	Digestib. (%)
5-Aug	0.34	0.52	5.4	1.06	46.4
15-Aug	0.36	0.45	5.5	1.11	46.6
27-Aug	0.36	0.44	5.2	1.06	47.2
5-Sep	0.41	0.44	4.8	0.97	46.4
12-Sep	0.36	0.45	5.2	1.01	45.7
20-Sep	0.32	0.41	5.0	0.96	45.7
25-Sep	0.30	0.41	5.1	1.02	46.3
12-Oct	0.35	0.40	6.6	1.19	47.2

RECOMMENDATIONS

The results indicate that a response to nitrogen would be expected in the dry season in the Great Dividing Range of SE Qld. It is recommended that a protein supplement be supplied to increase both protein and forage intake because of the lack of crude protein content for both maintenance and growth of cattle in the late Autumn-early Spring period. It is also recommended that, to maintain consistent growth in that period, an energy supplement (eg. molasses) be used.

The FNIRS sampling technique displayed minimal variation between the individual samples for the majority of attributes measured, indicating the current sampling technique of ten samples is sufficient to represent the sampled population.

REFERENCES

Coates, D.B. (2000). Faecal NIRS – what does it offer today's grazier? *Tropical Grasslands* 34: 230-239.

DIET QUALITY AND ANIMAL PERFORMANCE OF CATTLE GRAZING THE PILBARA RANGELANDS

P.C. Smith

Department of Agriculture, P.O. Box 1618, Karratha, WA 6714

INTRODUCTION

There is little documented information of the performance of grazing cattle in the Pilbara. Similarly there is no information on the quality of the diet that cattle actually select on the different land systems of the Pilbara. There is also little information on the reliability of faecal Near Infra-red Reflectance Spectroscopy (NIRS) as a tool to determine diet quality in the Pilbara rangelands.

A project, supported by Dept of Agriculture WA (DAWA) and Meat and Livestock Australia (MLA), to provide some base information on these issues was initiated in 2003. Cattle body condition, lactation status and simple pasture assessments are being recorded at regular (4 – 6 weekly) intervals at collection sites on some of the representative pasture systems of the Pilbara. Faecal NIRS is being used to predict diet quality of cattle grazing these pasture systems.

Results to date indicate that non lactating breeders have generally maintained body condition in areas that received useful summer rains. Faecal NIRS predictions at this stage of the project appear to be reflecting animal performance, as observed by changes in body condition of non lactating cattle at most sites. While dietary Crude Protein (CP) predictions declined to 5 –6% range at most sites during the year, predicted digestibility remained above 50% at all sites throughout 2003.

PROJECT OBJECTIVES

1. Establish initial animal performance 'benchmarks' of grazing cattle in the Pilbara region of WA.
2. Establish the reliability of faecal NIRS to predict animal performance and as a management tool in the Pilbara.
3. Produce a technical report, based on project outcomes, producer experience and best bet information, on the use of supplements in the Pilbara.

METHOD

Data collection sites have been established at stock watering points located in areas broadly representing three Pilbara pasture/land systems. Pasture photo monitoring sites have been established on each pasture/land system.

The body condition (1 – 9 scale) and lactation status, percent of mob lactating and estimated calf age of cattle watering at each 'collection site' is recorded at 4 – 6 weekly intervals. A bulked faecal sample is collected from at least 20 fresh dung pats at each site at each collection. Faecal NIRS predictions of diet quality provided by CSIRO, Townsville include; dietary crude protein (CP), faecal nitrogen (N), digestibility, non grass in the diet and live weight change.

Rainfall events, pasture assessments of yield, green:dry leaf ratio and leaf:stem ratio are also recorded at each observation. The pasture photo monitoring sites are recorded at three-monthly intervals to provide an indication of seasonal landscape changes.

Project progress is regularly reported to co-operating pastoralists for consideration in management decisions and to the broader rangeland community in our *Pastoral Memo* newsletter and at producer meetings.

PROGRESS TO DATE

1. A total of 15 collection sites have now been negotiated with seven pastoralists from different areas of the Pilbara.
2. Sample collections, recording of cattle body condition and some assessment of quality of grazing on offer commenced at the majority of these sites in November/December 2002.
3. Pasture photo monitoring sites have been established within the grazing area of collection sites.
4. Thirteen data collection 'rounds' have been completed on most sites.
5. Progress reports have been presented to Pilbara pastoralists at several meetings during 2003.
6. Information on the project has been published in the Dept of Agriculture WA *Northern Pastoral Memo* and the *NIRS Newsletter*, published by Queensland Department of Primary Industries & Fisheries (QDPI&F) staff involved in a similar project activity.
7. A pilot diet/faecal pair observation on cattle confined to a Spinifex-based pasture community has been conducted to determine the effectiveness of this type of observation to improve the accuracy of current calibration equations.
8. Communications with the QDPI team have been maintained and encouraged to ensure that information collected on both sides of Australia is comparable.
9. Project is currently progressing satisfactorily and it is anticipated that all currently agreed milestones will be met.

DISCUSSION

Three of the pastoralists co-operating in this project have included the information being collected in their management decisions for the timing of mustering and commencement of supplementation. Another pastoralist not involved in the project has submitted samples to assist in planning a supplementation program based on information generated by the project.

One co-operating pastoralist has indicated interest in developing a supplementation 'trial' to determine the cost benefit of supplements in his area. It is intended to weigh dry cattle on a regular (2 – 3 monthly) basis and collect regular faecal samples for NIRS determinations as part of this observation. This interest is encouraging for the future of NIRS as a management tool for the Pilbara.

Collations of condition changes of non lactating breeders and diet quality predictions from NIRS suggest that current NIRS predictions are useful cattle management tools for some rangeland pasture communities. These are pasture communities with significant areas of perennial tussock grasses including Buffel (*Cenchrus ciliaris*), Roebourne Plains (*Eragrostis xerophila*), Barley Mitchell (*Astrebla pectinata*) and Hoop Mitchell (*A. elymoides*).

Predictions of diet quality and predicted animal performance of animals grazing pasture communities including significant areas of Spinifex (*Troidia spp.*) appear to provide less reliable information. This is not surprising considering little diet/faecal pair information has been generated from these pasture communities for inclusion in the development of NIRS calibration equations.

The current project is providing information on where current NIRS predictions are likely to be useful in determining cattle performance in the Pilbara rangelands. It is also identifying pasture systems where more work is required to improve the accuracy and usefulness of predictions. An increased understanding of the diet quality that cattle grazing the Pilbara rangelands select during the year will form a basis for the development of improved cattle management systems to increase the production efficiency of Pilbara cattle herds in the future. This is likely to result in more efficient and environmentally responsible cattle production systems.

ACKNOWLEDGEMENTS

The support and co-operation of Pilbara pastoralists and the financial support of DAWA and MLA is gratefully acknowledged.

PILBARA RANGELAND SURVEY – THE BIGGEST SURVEY IN THE WEST

A.M.E. Van Vreeswyk [1] *and K.A. Leighton* [2]

[1] Department of Agriculture, Locked Bag No. 4, Bentley Delivery Centre, WA, 6983
[2] Department of Land Information, PO Box 2222, Midland, WA, 6936

INTRODUCTION

A joint team from the Department of Agriculture and the Department of Land Information has recently completed its largest endeavour yet - land classification, mapping and resource evaluation of 181,736 sq km in the Pilbara region in the State's north-west (Van Vreeswyk *et al.* 2004). Eighty-eight per cent of the pastoral rangelands of the state have now been covered by rangeland surveys.

With 44 pastoral leases covering about 58% of the survey area, pastoralism is the most extensive land use within the Pilbara. Mining is an economically important land use that is largely confined to ironstone ranges and greenstone belts. Areas set-aside for nature conservation cover about 9% and land set aside for aboriginal use covers about 6%. Large tracts of unallocated Crown land account for the remaining 27%.

LANDFORMS

Ranging from the coast to the desert, 102 land systems in 20 broad land types were identified and described in detail. The landforms comprise about 52% erosional surfaces and 48% depositional surfaces. They consist of extensive hill and plateaux tracts on sedimentary, igneous and metamorphic rocks above lower pediments and sheetwash plains. These drain into major river systems and their associated alluvial plains. Sandplains and dune fields are common particularly in the east. Coastal plains and beach dunes flank the coastal strip. For much of the area relief is subdued, interspersed with low to high (30-300m) hills and occasionally very high (>300m) rugged ranges (e.g. the Chichester Plateau and Ophthalmia Range). The Karijini National Park includes the spectacular dissected plateaux of the Hamersley Ranges. Drainage is organised and flow is seasonal and sometimes dramatic from cyclonic rains in the summer. All rivers flow generally north-westerly to the Indian Ocean. Landform patterns are best considered in terms of greenstone belts surrounded by extensive granitoid expanses and peripheral sedimentary basins that have undergone deep weathering and stripping.

VEGETATION

The vegetation of the Pilbara is essentially Eremaean. The central ranges and upland plains are dominated by spinifex hummock grasslands grading to pindan vegetation (*Acacia* shrublands with scattered trees and a grass layer) towards the north. To the south mulga (*Acacia aneura*) shrublands and woodlands prevail.

A total of 1,337 species of vascular plants were recorded representing 362 genera in 103 families. *Triodia pungens* was the most commonly recorded species in the northern, central and south western parts of the survey area, where it was recorded over 50% more often then the next most commonly recorded species: *Hakea lorea*, *Cenchrus ciliaris* and *Acacia inaequilatera*. In the south east part of the survey *A. aneura*, *Senna artemisioides* subsp. *helmsii*, *Solanum lasiophyllum* and the annual grass *Aristida contorta* were the most commonly recorded species.

Forty-four site types (an ecological classification based on plant community, soil type and landform) in eleven broad site type groups were identified and described in detail. Hummock grasslands were the most extensive site types comprising 57% of the land systems, followed by sclerophyll shrublands (17%), tussock grassland (12%), halophytic shrublands (8%) and drainage woodlands (6%).

The introduced *Cenchrus* grasses, buffel grass (*C. ciliaris*) and to a lesser extent Birdwood grass (*C. setigerus*) have become widely established in parts of the survey area, particularly the coastal plains and the floodplains of major rivers. It is estimated that the communities dominated by *Cenchrus* grasses cover about 3,400 sq km or 2% of the Pilbara.

RANGE CONDITION

Visual assessments of vegetation condition, and the type and extent of soil erosion were made at 12,448 traverse points at one kilometre intervals across the survey area. Approximately 77% of traverse records indicated good range condition, 11% indicated fair condition and 12% indicated poor condition.

Table 1 shows a summary of the resource condition in the survey area compared with other surveys undertaken by the regional survey team.

Table 1. Resource condition summaries for regional rangeland surveys.

Region surveyed (and year commenced)	Total area (sq km)	No. of traverse assessments	Severely degraded and eroded area (as mapped)		Resource condition classes (% of assessments)		
			sq km	%	Good	Fair	Poor
Gascoyne (1969)	63,400	2,426	1,205*	1.9*	32	53	15
West Kimberley (1972)	89,600	4,532	2,000*	2.2*	20	50	30
Eastern Nullarbor (1974)	47,400	1,273	0	0	50	10	40
Ashburton (1976)	93,600	8,608	534	0.6	50	34	16
Carnarvon Basin (1980)	74,500	10,952	647	0.9	45	32	23
Murchison (1985)	88,360	13,441	1,560	1.8	21	37	42
Roebourne Plains (1987)	10,216	1,172	233	2.3	51	27	22
North-eastern Goldfields (1988)	100,570	10,470	452	0.4	39	32	29
Sandstone-Yalgoo-Paynes Find (1992)	94,710	9,435	145	0.2	45	32	23
Pilbara (1995)	181,723	12,448	310	0.2	77	11	12
All areas surveyed	844,079	74,757	7,086	0.8	44	31	25

* Not mapped, estimate only.

The Pilbara survey area is in considerably better condition than other survey areas. Also the proportion of land which has been mapped as being severely degraded and eroded (about 0.2%) is considerably less than the proportion of severely degraded and eroded land across other survey areas. A large proportion of the Pilbara supports spinifex grasslands which are largely unaltered by grazing. A significant area is not used for pastoralism because it is inaccessible to stock or supports hard spinifex grasslands which are not grazed.

The most frequently observed impacts of pastoralism were loss in perennial species richness and perennial plant density. A less frequently observed impact was accelerated soil erosion. Major alterations to vegetation and consequent accelerated soil erosion were most frequently observed in tussock grassland and chenopod shrubland site types. These site types are preferentially grazed and often occur on alluvial plains that are inherently susceptible to soil erosion.

REFERENCE

Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. and Hennig, P. (2004). *An inventory and condition survey of the Pilbara region, Western Australia.* Department of Agriculture, Western Australia, Technical Bulletin No. 92.

AUTHOR INDEX

Author	Page