# Balancing Conservation and Production in Grassy Landscapes

Proceedings of the Bushcare Grassy Landscapes Conference
Clare, South Australia 19-21 August 1999

Edited by Tim Barlow and Roberta Thorburn

# Balancing Conservation and Production in Grassy Landscapes

Proceedings of the Bushcare
Grassy Landscapes Conference
Clare, South Australia
19-21 August 1999

Edited by Tim Barlow and Roberta Thorburn

The conference was organised and funded by Bushcare,
a program of the Commonwealth Government's Natural Heritage Trust

Bushcare

AUSTRALIA

Natural Heritage Trust

*Helping Communities Helping Australia*

Published by Environment Australia:
Biodiversity Group
GPO Box 787
Canberra ACT 2601
Telephone: 1800 803 772
Fax: (02) 6274 1970
Email: ciu@ea.gov.au



Publication data

Barlow, T. & Thorburn, R. (eds) 2000. Balancing Conservation and Production in Grassy Landscapes. Proceedings of the Bushcare Grassy Landscapes Conference, 19-21 August 1999, Clare, SA. Environment Australia, Canberra.

Cover illustration by Brian Bainbridge
(with permission of Trust for Nature (Victoria))

Printed by Elect Printing, ACT

Designed and typeset by Fusebox Press

ISBN: 0 642 19478 5

Printed on recycled paper

# Acknowledgments

The planning and organisation of this conference involved a cast of thousands. Thanks to the many people who contributed their ideas.

The following people deserve a special mention:

The Council for Sustainable Vegetation Management for their support for and participation in the conference.

The speakers and poster presenters for taking the time and contributing to costs to attend the conference and share their knowledge, experiences and enthusiasm for grassy ecosystems.

Ann Prescott and Millie Nicholls (World Wide Fund for Nature Australia) for organising and running the field trip to South-Australia's Mid-North, and to the local farmers and graziers for inviting us onto their properties to see the theory in action. Thanks also to the staff of the SA Department of Environment, Heritage & Aboriginal Affairs for their assistance with transport for the field trip.

The Conference Organising Committee (and their respective organisations) who survived the sometimes arduous task of organising a conference entirely by email and teleconference:

| | |
|---|---|
| Vanessa Craigie | Department of Natural Resources & Environment, Victoria |
| David Eddy | World Wide Find for Nature Australia, ACT/NSW |
| Denys Garden | NSW Agriculture |
| Louise Gilfedder | Department of Primary Industry, Water & Environment, Tasmania |
| John Lumb | Environment Australia, ACT |
| Ian Lunt | Charles Sturt University, NSW |
| Ann Prescott | World Wide Fund for Nature Australia, SA |
| Andrew Walker | Agriculture, Forestry & Fisheries Australia, ACT |
| Lyn Wilks | Bushcare Link, ACT |

We are grateful to Intercomm Event Coordination and particularly to Anna Handley who kept the show on the road and maintained her good humour despite the string of complexities that we threw at her.

Finally, we'd like to thank the delegates for travelling (from all over Australia) to Clare, South Australia to share their passion for Australia's native vegetation and for the better integration of conservation and production goals in our grasslands and grassy woodlands.

# Table of Contents


Introduction v

Authors' biographies vii

Welcoming address 1
*The Hon. Dorothy Kotz,*
*SA Minister for the Environment and Heritage*

Opening address 3
*Senator the Hon. Robert Hill, Commonwealth Minister for the Environment and Heritage*

Session 1: Setting the Scene 7

Farming with nature (1) 8
*Lindsay Nicolson*

Farming with nature (2) 11
*Biz Nicolson*

Biodiversity does matter 14
*Denis Saunders*

Session 2: The Two-Edged Sward 19

Native grasslands – a South Australian perspective 20
*Millie Nicholls*

Native grasslands in Tasmania 24
*Cynthia & Tom Dunbabin*

Monaro, NSW – A question of need 28
*Charles Litchfield*

Native grasslands on the Victorian Basalt Plains 34
*Val Lang*

Native grasslands – who needs them? 37
*Owen Whitaker*

Session 3: Biodiversity of the Grassy Landscape 41

Bats in rural landscapes: a significant but largely unknown faunal component 42
*Lindy Lumsden & Andrew Bennett*

Plains-wanderers, native grasslands and biodiversity 51
*David Baker-Gabb*

Sun Moths in the back paddock 56
*Fabian Douglas*

Conservation Management Networks – a model for coordinated protection and management of remnant vegetation 58
*Kevin Thiele & Suzanne Prober*

The significance and weed management of temperate native grasslands and box grassy woodlands in SA 64
*Rick Davies*

Management of the Pygmy Bluetongue Lizard (*Tiliqua adelaidensis*) on private grazing properties, Mid-North SA 70
*Sylvia Clarke*

Session 4: The Nature of the Business 73

Grazing management of native pastures in hill country (abstract only) 74
*Simon Ellis*

The farm business and natural resource management 75
*Jim Crosthwaite*

Marketing opportunities 82
*Geoff Watson*

Creating private markets for nature conservation 87
*Carl Binning*

Session 5: Looking Back: Moving Forward 97

Indigenous land management perspective on conservation and production 98
*Adrian Stanley*

Community perceptions of grassy vegetation 101
*Kathryn Williams*

Rediscovering the past and making a future 108
*Martin Driver*

A guide to best practice conservation of temperate native grasslands 113
*James Ross*

Session 6: Managing Native Pasture 123

Balancing pasture development options for landscape diversity 124
*Peter Simpson*

Perennial native grasses – the quiet achievers 133
*Bill Johnston*

Cropping native pasture and conserving biodiversity: a potential technique 142
*Christine Jones*

Managing grassland composition with grazing 145
*David Kemp*

Session 7: A Broader Look at Grassy Landscapes 153

Conservation of biodiversity in grazed landscapes: some patchy principles 154
*David Freudenberger*

Ecological limits to pasture intensification 162
*Sue McIntyre*

Perennial farming systems 170
*Ted Lefroy*

Maintaining tree cover health in temperate pastoral landscapes 177
*Nick Reid*

Poster abstracts (in alphabetical order) 189

# Introduction

Grassy landscapes occur on the fertile plains, foothills and tablelands that for most Australians typify the farming environment (the rangelands of the 'outback' are in a different category). With few exceptions, farming activity has been so extensive that the original ecosystems of these regions have become highly fragmented, with many plant and animal species continuing to decline in number and extent.

Increasingly, the fragmentation of habitat and extinction of populations is manifesting as disrupted ecological processes that also threaten the economic viability of farms and rural communities. For example, weed invasion is estimated to cost Australian agricultural production some $3.5 billion per year. Salinity is another obvious problem of great economic cost, and it is estimated that up to 30% of the arable land in Australia will become salt–affected unless there is significant intervention.

For the remnants of the original ecosystems to survive, it is imperative that nature conservation becomes a normal part of farming operations. It is also argued that, for farming itself to survive, production objectives need to be more fully integrated with nature conservation.

The goal of Bushcare is to reverse the long-term decline in the quality and extent of Australia's native vegetation cover. It is therefore appropriate that Environment Australia, which manages the Bushcare Program, convene a conference that explores the social, economic and ecological issues involved in balancing nature conservation and agricultural production.

The conference Balancing Conservation and Production in Grassy Landscapes was divided into seven sessions, each of which contained four or five speakers invited to present a given topic relevant to their area of expertise. The first session, Setting the Scene, is introduced by the Hon. Dorothy Kotz, South Australian Minister for the Environment and Heritage, and fellow South Australian, Senator the Hon. Robert Hill, Commonwealth Minister for the Environment and Heritage, who outlines the role of Bushcare in balancing nature conservation and agricultural production. Biz and Lindsay Nicolson present their views on what it means to be 'on the land', in their case the Northern Midlands of Tasmania.

Denis Saunders then explains what biodiversity really means as a term, and for the maintenance of essential, life-supporting ecological processes.

The Two-Edged Sward includes presentations from farmers from various regions across South-eastern Australia, each giving their own perspective on balancing conservation and production. As Cynthia Dunbabin states 'it's hard to be green if you're in the red'. An issue of ubiquitous concern is the socially crippling exodus of young people from rural communities.

Despite the fragmentation and impoverishment of natural ecosystems, the Biodiversity of Grassy Landscapes still supports an array of biological treasures, including the mysterious sex-life of the Pale Sun Moth and the cryptic habits of our bat fauna. Conservation strategies, whether for a single species such as the Plains-wanderer or an entire ecosystem such as the White Box Woodlands, reveal the importance of including socio-economic issues, and adopting a flexible approach in conservation planning.

Gaining an understanding of the socio-economics of the farm enterprise is the purpose of The Nature of the Business, wherein we explore a range of issues from creating marketing advantages, to the strategic delivery of conservation incentives. In Looking Back: Moving Forward we consider the potential importance of 'evolutionarily-acquired' attitudes to grassy landscapes, and the on-going relationships of Indigenous Australians with this land. Both the long-past and most recent experiences will help determine our abilities to better integrate conservation and production.

The final two sessions are both pragmatic and profound. Managing Native Pastures examined concepts relating to knowing your plants and utilising 'ecological windows' to achieve a range of objectives from manipulating pasture composition through to non-destructive cropping of degraded native grasslands. A Broader Look at Grassy Landscapes includes consideration of the $20 billion worth of trees standing in the grassy landscape and threatened by dieback. Limiting pasture intensification to about 30% of any one property could potentially rectify this and maintain sufficient patchiness in the landscape to provide for the majority of plant and animal habitat needs.

Ultimately though, we must develop a more diverse and stable agricultural system if this balance of biodiversity and production is to be achieved.

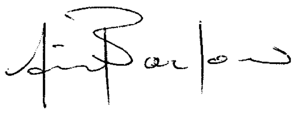
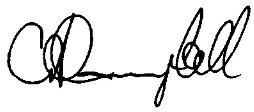
These Proceedings are a record of the presentations given at the conference. We have endeavoured to allow the full 'flavour' of each presentation to come through to the written form. It should be noted that editorial input has been limited to mostly typographical matters and papers have not been subject to external refereeing.

One person with extensive experience in natural resource management in the NSW Riverina stated it was 'the most important couple of days I've had in the job in the last 10 years'. As editors, we are proud to be able to put this claim in print, and we know it represents the feeling of many at the conference.

We would like to publicly thank our colleagues on the Conference Organising Committee:

Vanessa Craigie, David Eddy, Denys Garden, Louise Gilfedder, John Lumb, Ian Lunt, Anne Prescott, Andrew Walker and Lyn Wilks.

Most especially, we thank and acknowledge the presenters for the time, wisdom, and enthusiasm they gave so generously, for it is they who made the conference such a success.

Roberta Thorburn
Conference Convenor
Sustainable Landscapes Branch
Environment Australia

Tim Barlow
Bushcare Grassy Ecosystems
Networker (South-east Australia)
Victorian National Parks Association

Andrew Campbell
Assistant Secretary
Sustainable Landscapes Branch
Environment Australia

# Authors' biographies

### David Baker-Gabb

Dr David Baker-Gabb is a self-employed ecologist with a special interest in threatened species and land management. These interests have evolved from his life-long passion for birds and from his farming background. He currently chairs four recovery teams for threatened birds, writes species recovery plans and reserve management plans, and does lots of related volunteer work. He is the Council member of BirdLife International, representing the Pacific region, and the honorary Conservation Adviser to Birds Australia. David's work experience includes: 1993-97 Director of Birds Australia (RAOU); 1989-92 Senior Wildlife Planner with the Victoria Government; 1983-88 professional ornithologist with RAOU; and 1979-82 PhD at Monash University.

### Carl Binning

Carl Binning is a senior research economist at CSIRO Wildlife and Ecology. His research is focused on designing economic incentives and institutions for sustainable natural resource management, focussing on the conservation of biodiversity outside public nature reserves. In the last three years he has undertaken a detailed evaluation of the potential role of innovative policy instruments, such as covenants, management agreements and financial incentives, in securing voluntary private investment in nature conservation.

Prior to joining CSIRO, Carl worked as an environmental economist within the Commonwealth Environment Department and the Department of Prime Minister and Cabinet. In this period, he participated in the Ecologically Sustainable Development process, the Council of Australian Governments Water Reforms and the development of Regional Forest Agreements.

### Slyvia Clarke

Sylvia Clarke has a Bachelor of Science, with a major in Environmental Biology, from the University of Adelaide. In 1997 she completed Honours in the Department of Zoology with Associate Professor Keith Walker, looking at the effects of salinity, drought and insect herbivory on the ecology and ecophysiology of eucalypt seedlings. She has been working as the Project Officer for the Pygmy Bluetongue Lizard Recovery Program at the South Australian Museum since mid-1998.

### Jim Croshwaite

Jim Crosthwaite is currently doing a PhD titled 'Reconciling Public and Private Interests: the Case of Native Grasslands'. This research builds on a recently completed two year LWRRDC/Environment Australia funded project on the same topic. Jim worked for eight years in the Victorian Department of Natural Resources and Environment, ensuring that conservation plans accounted for social and economic matters, as required under the Flora and Fauna Guarantee Act. Earlier he managed the Agricultural Census (Victoria) in the Australian Bureau of Statistics and wrote a Masters thesis titled 'The Persistence of Family Farming: Land, Cows and Capital in Victorian Dairying 1945 to 1975'. Recently he wrote *The Dairy Industry* for the Oxford Companion to Australian History.

### Rick Davies

Rick Davies has worked as a botanist in South Australia and Victoria for twenty years, specialising in research into threatened plant communities, threatened plant species and native vegetation management. He has undertaken an extensive field and literature based experimental study into weed management in native grassy ecosystems, published in his book *Weed Management in Temperate Native Grasslands and Box Grassy Woodlands in South Australia*.

Rick is currently working as a Biodiversity Extension Officer with the Nature Conservation Society of SA, coordinating the biodiversity component of the Bushcare Support Program in South Australia.

### Fabian Douglas

Fabian Douglas is a freelance entomologist with a special interest in the conservation and management of endangered species. He is particularly concerned about insects that depend on threatened habitats for their survival and has carried out a number of entomological surveys in such areas during the past twelve years. Fabian is also in the process of doing a Master of Science degree at the University of Ballarat. His study focuses on the biology, taxonomy, distribution, habitat requirements and conservation of the Pale Sun Moth (*Synemon selene*).

### Martin Driver

Martin Driver has been the Regional Manager of Greening Australia (Riverina) for nine years. During that time he has worked closely with the Murray Catchment Management Committee (MCMC) in fostering natural resource management programs and awareness. Greening Australia and the MCMC were instrumental in establishing broad vegetation assessment programs and the implementation of the Fencing Incentive and Management/Vegetation Enhancement Incentives. These programs have since been adopted by Catchment groups across NSW. Greening Australia (Riverina) offers a range of incentives and support, through core Bushcare, Seedbank and Fencing Programs, to enhance nature conservation values while balancing production capacity on private land.

Martin worked with CSIRO Division of Wildlife and Ecology for fourteen years prior to joining Greening Australia. He is an active partner in a dryland grazing property in the NSW Riverina. His interests on the property include extensive regeneration and vegetation management projects for both nature conservation and production outcomes through increasing the perennial vegetation base.

### Cynthia & Tom Dunbabin

Cynthia and Tom Dunbabin manage 'Bangor', a family property in Tasmania's south east. The major enterprise is grazing sheep, for both wool and prime lambs, and beef cattle. Other enterprises include forestry, vegetable seed crops and farm tourism. Cynthia has undertaken a number of farm related training courses, including property management planning, Prograze and farm forestry. A special interest at Bangor is the conservation of the rich natural and cultural heritage of the area.

### Simon Ellis

Simon Ellis is a private farm consultant with 20 years experience in the sheep and beef cattle industries, and an extensive knowledge of grazing management in hill country. He has a unique understanding of animal production from both the environmental and the commercial agriculture perspectives.

Simon offers a range of services to commercial producers across South Australia, including farm financial review, farm planning, pasture and animal productivity, animal breeding and landcare issues. He is currently managing the South Australian site of the Murray Darling Basin Commission–funded project 'Management of Grazed Key Native Pasture Communities in the Murray Darling Basin'.

### David Freudenberger

Dr David Freudenberger is a Senior Research Scientist with CSIRO Wildlife and Ecology's Sustainable Landscapes Program, Canberra. David's current research is focused on developing revegetation guidelines in the Southern Tablelands of NSW and the wheat–sheep zone of eastern Australia. This work is in partnership with Greening Australia, NSW National Parks and Wildlife Service and the Lachlan Catchment Management Committee, with support from the Natural Heritage Trust. David is also involved in long-term ecological research into the impacts of grazing on landscape function in the rangelands.

### Bill Johnston

Bill Johnston graduated from the University of New England in 1991. Bill's main area of interest is agricultural ecology, particularly the use of summer active grasses in pastures. Bill developed Consol Lovegrass and was project leader for the low input grasses LIGULE project. He is also project leader of an NRMS–funded research project examining management of grazed key native grasslands in the southern sector of the Murray-Darling Basin.

### Christine Jones

Christine Jones' first degree was through the University of New South Wales (wool and pastoral sciences). She obtained her PhD through the University of New England (crop and weed management). Over the past twenty-five years, Christine's principal interest has been the investigation of integrated management practices that regenerate soils and vegetation. Most recently this has involved exploring appropriate grazing management strategies for grasslands, and the combined farming/grazing methodology of perennial pasture cropping for farmed areas. Christine undertook a three week lecture tour in the USA in 1998 giving seminars on these topics, and presented a paper on permanent groundcover farming at the International Women in Agriculture Conference in Washington DC.

## David Kemp

David Kemp has a PhD in agriculture. He was recently appointed to the foundation Chair in Farm Management at the University of Sydney, Orange Campus. In this position, he aims to develop a more sustainable approach to Farm Management and to achieve better integration of financial, biological, physical and social aspects of farming systems. Prior to taking up this appointment, David worked with NSW Agriculture.

In central NSW, David has worked on improving the competitiveness of wheat crops through varying spatial arrangements and density. Over the last fifteen years his work has returned to a more ecologically based approach, aiming to improve the productivity, stability and sustainability of pastures and grasslands. This work has been central to the large Key Programs, Temperate Pasture Sustainability and Sustainable Grazing Systems (SGS) funded by Meat & Livestock Australia and other R&D Corporations. David was also involved in establishing the CRC for Weed Management Systems and was the Leader of the Perennial Pasture Ecosystem Program within the CRC until March 1999. The work at Orange has been in the forefront of developing grazing management practices to improve or maintain the composition of perennial pastures. An important component is the development of better advisory tools for managing grasslands. David is leading a study across all the SGS sites of the impact of management treatments on plant and soil invertebrate biodiversity. He recently completed a three year term on the Scientific Committee established under the Threatened Species Act in NSW.

## Val Lang

Val Lang and her family's livelihood depends on their cropping and grazing enterprise in the grassy landscape of Western Victoria. She is also the Chair of the Victorian National Trust's Mooramong Nature Reserve Committee and a past member of the Corangamite Catchment and Land Protection Board.

## Ted Lefroy

After graduating from the University of WA with a degree in agricultural science in 1973, Ted Lefroy worked in agricultural extension in Queensland and Papua New Guinea and in horticulture at the Royal Tasmanian Botanical Gardens in Hobart. In 1985 he returned to WA and began working as a consultant to Landcare groups in farm and catchment planning. He is currently a research fellow at the Centre for Legumes in Mediterranean Agriculture at the University of WA, studying the development of farming systems as mimics of the natural woodland ecosystems of the Western Australian wheatbelt.

## Charles Litchfield

Since graduating from Sydney University, working in the financial markets in Sydney, and returning to the family farm near Cooma in 1990, Charles Litchfield has been involved in a number of producer and community organisations. He was Vice President of the Beef Improvement Association of Australia between 1994 and 1996 and is a graduate of the Australian Rural Leadership Program.

Charles has had broad involvement in resource management, from input to the Monaro Grasslands Management Plan to coordinating the Upper Snowy Landcare Committee, and is currently undertaking an action planning project for the Snowy region, with the Snowy Genoa Catchment Management Committee, local government and community.

## Lindy Lumsden & Andrew Bennett

Lindy Lumsden has been studying insectivorous bats for 20 years. She has worked extensively throughout Victoria, as well as elsewhere in Australia and overseas. In the last 6 years she has been undertaking research on the fauna of the Northern Plains and Box-Ironbark regions of Victoria, including a major study on the conservation of insectivorous bats in rural landscapes.

Andrew Bennett is a leading expert on landscape ecology and wildlife in remnant habitats in rural landscapes. He is the author of a recent book *Linkages in the Landscape: the role of corridors and connectivity in wildlife conservation*, published by the IUCN.

## Sue McIntyre

Sue McIntyre is a Principal Research Scientist at CSIRO Tropical Agriculture, Brisbane. She has 18 years experience in ecological research with the University of Melbourne, University of New England and CSIRO. She has published over 50 papers on the relationship between native vegetation, introduced plants and human management. Her most recent research has focused on integrating management for natural resource conservation and production in grazing lands, with particular emphasis on native grasslands. Sue is currently a member of the Council for Sustainable Vegetation Management.

### Millie Nicholls

Millie Nicholls has lived on farms in South Australia's Mid-North all her life, and for the last 25 years has been an active partner in a farming and grazing enterprise near Clare. Increasing frustration at not being able to find any information on the native grasses on the family property led her to completing a Batchelor of Science degree at the University of Adelaide as a mature age student. For the past two years, Millie has been working as an Extension Officer with the World Wide Fund for Nature's Mid-North Native Grasslands Project.

### Lindsay & Biz Nicolson

Lindsay and Biz Nicolson are farmers from 'Bonneys Plains', Conara, in Tasmania's Midlands district. 'Bonneys Plains' (2300 ha) is a traditional sheep grazing enterprise, which has been recognised with State and National Landcare awards. Biz and Lindsay own 'Taz Wild Plants' nursery, specialising in local provenance native species with emphasis on understorey plants. Their company 'Tasmanian Revegetation Services' undertakes projects with individuals, community groups and local government to implement revegetation on a broader scale.

### Nick Reid

Nick Reid is an Associate Professor in, and Convenor of, Ecosystem Management at the University of New England, where he teaches sustainable land management, agroforestry and farm forestry, and park and wildland management in the Natural Resources degree programs. His recent research has focused on the ecosystem function of trees in temperate native pastures, but he maintains active research interests in mistletoe ecology and management as well as in his teaching areas. Current PhD and Masters students are working on: *Eucalyptus radiata* plantation management for medicinal oil production; fire management guidelines for plant conservation in northern NSW wilderness; environmental impacts of pastoralism and mining at Roxby Downs; tree–nutrient–pasture and tree–soil moisture–pasture interactions on the Northern Tablelands of NSW, and management impacts on rare native herbs in New England.

### James Ross

James Ross has a peculiar mix of qualifications in Law, Science and Horticulture. He was the Grassland Project Officer at the Victorian National Parks Association for six years and led the Association's successful campaign for new national park areas in the Victorian Mallee. He currently works as an environmental consultant and has recently completed projects for the World Wide Fund for Nature, Australian Bush Heritage Fund and the Victorian Department of Natural Resources and Environment. He remains passionate about the flat parts of Victoria.

### Denis Saunders

Dr Denis Saunders is an Assistant Chief of CSIRO Wildlife and Ecology. He has a strong commitment to conservation biology and to communicating landscape ecology and conservation to all members of the community. He has considerable research and community background in issues associated with the conservation and management of remnant native vegetation and associated fauna.

Denis chaired the reference group that prepared the chapter on biological diversity for the 1996 Australian State of the Environment Report, and, more recently, has drafted a set of indicators of biological diversity for national state of the environment reporting. He is currently a member of the Biological Diversity Advisory Council (a Commonwealth Ministerial Council) and an Australian Heritage Commissioner.

He was the recipient of the International Society for Conservation Biology's 1998 Individual in Government award for making 'significant, meaningful and lasting contributions to conservation biology.' This year he was awarded the International Association for Landscape Ecology's 1999 Distinguished Scholarship Award for 'exceptional contributions to the development of landscape ecology as a science and a practice.'

### Peter Simpson

Peter Simpon has been employed with NSW Agriculture since 1961, primarily as District Agronomist. Most of his working career has been spent on the high rainfall tablelands of New South Wales at Glen Innes, Orange, Bathurst and Goulburn.

Peter has been extensively involved in evaluating pasture improvement strategies with introduced species, but since observing the drought recovery effects of a wide range of pasture types in 1982, he has been increasingly interested in understanding native pasture management systems and where they fit into the landscape.

Peter has been actively involved in industry–funded projects during the last 10 years, evaluating herbage quality, acid soils tolerance, herbicide tolerance, and non-destruction methods of developing native pasture based systems.

### Adrian Stanley

Adrian Stanley is currently a Research Assistant within the Policy and Research section of the Indigenous Land Corporation. He is also studying part time, undertaking an Honours degree at the University of Adelaide. The main focus of his thesis is Aboriginal and non-Aboriginal use and knowledge of fire. The principle aim is to combine the knowledge of both groups and create a fire regime for South Australia.

Adrian was born in Naracoorte in the South-east of South Australia, and has connections with Queensland. Adrian has held numerous positions from working in the building industry to working at Batchelor College as a lecturer in Natural and Cultural Resource Management.

### Kevin Thiele & Suzanne Prober

Kevin Thiele is a botanist with a PhD from Melbourne University, specialising in systematics. Suzanne Prober is a botanist with a PhD from the Australian National University, specialising in the ecology of rare plants and ecosystems. Together they constitute Ecological Interactions, a small consultancy partnership. First at CSIRO and later freelance, they have worked for over ten years studying the ecology, and facilitating the conservation, of the grassy White Box Woodlands of New South Wales. This currently involves a partnership with NSW National Parks and Wildlife Service in a project, funded by the Natural Heritage Trust, to develop a new model—the Conservation Management Network model—for conserving fragmented, threatened ecosystems.

### Geoff Watson

Dr Geoff Watson is Senior Lecturer in Marketing at Orange Agricultural College, the University of Sydney, with key interests in: marketing practice within farmer groups and agribusiness; strategic marketing and supply chain management; board policy governance for profit and not-for-profit organisations; environmental marketing approaches for remnant bushland; action learning/action research as methodologies for undertaking change management and building learning organisations; and facilitating strategic planning and change for individuals and groups.

He consults extensively to companies and organisations both within Australia and overseas and was design coordinator for the 1999 NSW Dairy Business Focus Extension Program, which integrated strategic management and action learning for change management in dairy businesses. Geoff has participated in the delivery of courses in relationship marketing to ranchers from the USA and Canada, and in NSW Agriculture's Rural Leaders Industry Training Course.

Geoff is currently focussed on the development of value chain thinking within agribusiness industry. He is a member and past Branch President of the Australian Marketing Institute, a member and past National President of the Agriculture Information Association of Australasia as well as a member of the Australian Agribusiness Association and book review editor for the Australian Agribusiness Review.

### Owen Whitaker

Owen Whitaker is a fourth generation farmer, practising beef cattle and prime lamb production with cereal and grain legume cropping. For the last 20 years he has integrated natural and introduced biodiversity with general farm management, that is, multi-species, perennial pasture establishment, trees for timber, shelter and fodder, and grazing 120 ha of native grassland for conservation and profit. This area is now recognised as a significant remnant native grassland. Owen has recently purchased another property, near Yass, that contains diverse native grassland/woodland structures, for which management including grazing of both fauna and livestock is still being developed.

Owen is also a Project Officer in the Upper Murrumbidgee for the Remnant Vegetation Fencing Incentive with Greening Australia, resourcing landholders, from Yass to Adaminaby, with funds and bush management extension.

He sees the future of farming dividing in two paths: ever increasing 'per unit' production expectation involving manipulation and elimination of ecosystems at great risk to our own species; or farming with a truly sustainable imperative for the future that embraces preservation of remaining natural landscapes.

## Kathryn Williams

Kathryn Williams is a teacher and researcher at the University of Melbourne. She has a PhD in environmental psychology from Monash University. Kathryn's research is concerned with psychological aspects of land management, with a particular focus on human relationships with natural places.

# Welcoming address

*The Hon. Dorothy Kotz*

*South Australian Minister for the Environment & Heritage*

Firstly, let me welcome you all to the beautiful Clare Valley for this national conference. In particular, welcome to our interstate delegates. I trust that your stay will be enjoyable and rewarding.

It is appropriate that this national conference, focussing on balancing conservation and production in grassy landscapes, should be held in Clare, the heart of the Mid-North region of south Australia.

For too long we have underestimated the important role that grasslands play in our ecosystem. It is very fitting that this conference should be held here in the Mid-North, where grasslands make such a dominant contribution, both to the landscape and to the economy.

It is estimated that grasses are the main vegetation type for around 500,000 hectares of land in the Mid-North region. This is partly a result of the north-south running ranges traversing the region, which have retained large remnant areas of native grasses as the basis of grazing paddocks.

As a community, we now face some important decisions as we consider the best way of conserving these important grasslands.

More than 98% of all native grasslands are on private property and nearly all of these are grazed by stock. Consequently, the quality of grasslands varies enormously.

The remaining 2% of grasslands on public land and roadsides have therefore assumed a disproportionately high conservation value. We are fortunate in that past management decisions, particularly low grazing regimes and minimal fertiliser applications, in these areas have retained species richness and diversity, which have allowed for retention of species with high conservation value.

This Government has been particularly pro-active in seeking to conserve grassland areas. I am especially proud of our acquisition of the Mt Cone Station through the Comprehensive Adequate Reserve Strategy for South Australia. Mt Cone is an area of 464 hectares of native grasslands near Burra that the State Government purchased in December 1998 as the State's first native grassland park, now known as Mt Cone Conservation Park.

Purchase of the land was made possible through funds provided by the State and Commonwealth via the National Reserve System Program of the Natural Heritage Trust, the Native Vegetation Council, and through the contributions of the National Parks Foundation of South Australia.

The National Parks Foundation is a voluntary group that fundraises and attracts corporate sponsorship to support the National Parks System in South Australia and raises community awareness of conservation projects.

The Foundation not only contributed $50,000 towards the purchase of Mt Cone, but has also sponsored two other native grassland projects in the region.

A baseline biological survey of native grasslands at Mt Cone is being conducted as a joint project involving the Nature Conservation Society, the Threatened Plant Action Group and the National Parks Foundation. This is a great example of collaboration and I look forward to looking at the results of the survey.

In another part of the Mid-North, the Parks Foundation have recruited students from Snowton Area School to work with Ann Prescott and Millie Nicholls to fence and reserve areas of native grassland in the local district, with the help of farmers who own the land.

The Foundation is to be congratulated for the wonderful support they have given towards acquiring the land for Mt Cone Conservation Park and for assistance with other projects.

The Mt Cone project does not stand in isolation and, through the Natural Heritage Trust, both the State and Commonwealth Governments have supported a number of projects that aim to assist the community to conserve grasslands and regional biodiversity.

Development of community awareness and support is vital to the conservation of our natural ecosystems, and in this instance, our grasslands.

To this end, the government is undertaking a number of projects to raise awareness of grassy ecosystem management in the Northern Agricultural Districts.

Firstly, a Biodiversity Plan for the Northern Agricultural District is being developed to help prioritise conservation actions for the region.

To support the development of the Biodiversity Plan, along with a number of other grasslands conservation projects, we will also be making available a Regional Ecologist for the Yorke/Northern Agricultural Districts.

I am also delighted to see the establishment of a local Grasslands Reference Group to oversee regional grasslands projects. The Group will be:

- investigating conservation and sustainable management projects;
- implementing best practice methods for grassland production and conservation;
- establishing and maintaining links with other groups involved with the same conservation and management issues; and
- providing a community voice in grasslands conservation issues.

The Group have held an initial meeting, but I encourage any of you who may be interested to get involved.

We need to develop programs to demonstrate to landholders the value of maintaining and improving biodiversity values that will not impact negatively on landholders' economic returns.

This can be done through the provision of incentives such as Heritage Agreements over grassland areas. The Biodiversity Plan should assist us in identifying priority areas and then developing appropriate options.

State Heritage Agreements have already seen the protection of some 50 hectares of our native grasslands through Agreements and a further 100 hectares through voluntary management agreements.

Local landholders are also protecting or enhancing more than 500 hectares of native grasslands.

Greening Australia, the Nature Conservation Society and Trees for Life have also provided wonderful support and, through their contract with Environment Australia, have been conducting programs on grassland identification in the region.

The conservation and management of our native grasslands is of major importance across southern Australia. This conference, simply by being held in South Australia, recognises that grasslands exist beyond the eastern seaboard and the Commonwealth is to be congratulated on holding the conference in Clare.

I hope that the conference provides you all with an opportunity to share and learn about grasslands management and conservation, and that you all come away as better informed grasslands managers.

# Opening address

*Senator the Hon. Robert Hill*

*Commonwealth Minister for the Environment & Heritage*

The Honourable Dorothy Kotz, Dr Nigel Monteith, other members of the Council for Sustainable Vegetation Management, ladies and gentlemen: it is a great pleasure to be here today in Clare to set the scene for what promises to be a very productive and rewarding Bushcare conference.

I'm very sorry that I cannot stay with you for the whole conference, as I have a Wet Tropics Ministerial Council meeting in Cairns tomorrow and Saturday. The Wet Tropics are a special place, with extraordinary biodiversity and spectacular landscapes, which most people would agree are deserving of their own Ministerial Council.

But it saddens me that much of Australia's environmental consciousness, energy and focus is concentrated on symbolic icons such as the Wet Tropics, when ecosystems such as native grasslands and grassy woodlands are far more depleted, degraded, fragmented and threatened, just as precious a part of our natural heritage, and just as, if not more, important to the ecological integrity of a very large part of our continent.

So I am particularly pleased that the focus here is on native grasslands, which to me crystallise many of the conservation issues we are grappling with through the Natural Heritage Trust.

The Natural Heritage Trust and its programs such as Bushcare are about dealing with the whole landscape and the full spectrum of sustainable production and biodiversity conservation issues, from ferals and weeds, erosion and salinity, to habitat conservation and enhancement. The Trust covers those vast areas of the continent outside the conservation icons that are largely protected in conservation reserves.

Other speakers can cover better than I the ecology and management of native grasslands. My challenge as Minister for the Environment is how we as a nation can value more appropriately all our ecosystems and the services they provide us, across entire landscapes—terrestrial, coastal and marine. Today I want to look at these broader issues, through the prism of our treatment of native grasslands.

Grassy landscapes are a great window to look through because they exemplify so many of the really hard issues. Grassy landscapes were among the first developed after European settlement; they have been profoundly depleted and degraded; they continue to be subject to intense development pressures; they are overwhelmingly managed for primary purposes other than conservation; and their charms are generally subtle—they are not charismatic icons that capture the public imagination like the Wet Tropics, the Franklin or the Reef. For all these reasons, grassy landscapes are poorly represented in our formal conservation reserves.

Take the yam daisy, or *murnong*, a little yellow daisy resembling a European dandelion, which once grew throughout the grasslands of Victoria and New South Wales.

Records extending back to the 1840s list it as occurring in most regions of Victoria. One settler reported 'millions of murnong or yam, all over the plains'. The roots, called tubers or yams, are like carrots or radishes and grow at a shallow depth. They are easily dug up and are quite nutritious. These tubers were among the most important components of the Aboriginal diet.

Things changed with European settlement. Sheep liked the yam daisy and learned to dig up the tubers. In a matter of years the plant became scarce in many areas. Eventually, the yam daisy disappeared—even in areas where native grasses persisted.

The impact on the Aborigines was significant. One European observer noted, and I quote: 'Murnong and other valuable roots are eaten by the white man's sheep, and their [Aborigines] deprivation, abuses and miseries are daily increasing'.

Today the yam daisy is completely absent from the open plains where it once thrived and is found only in small, ungrazed, isolated remnants.

Of course agricultural and pastoral production was very important to the development of Australia. Our cultural history records that Australia rode to riches on the sheep's back, and most of those sheep grazed on the grasslands of South-eastern Australia, from this very region with its great merino studs to the Darling Downs in Queensland. Our native grasslands and grassy woodlands, referred to so memorably by Major Mitchell as 'Australia Felix', underwrote wealth generation in a prosperous young nation.

But Mitchell traversed the country in a good season. The park-like landscape he surveyed and reported on in such glowing terms was nowhere near as productive, reliable and forgiving as it appeared. Its variable climate and its vulnerability in the face of cultivation, hard-hoofed grazing animals and irrigation were in stark contrast to the deep young soils and gentle misty climes of Mitchell's homeland.

We didn't understand the value of these native pastures and the variability of the Australian climate as well as we might have. Nor did we understand the processes that maintained the open grasslands and grassy woodlands. These dry grassy landscapes had been shaped by the extensive, low impact management of the Aboriginal inhabitants over millennia. Aboriginal people undoubtedly changed the landscape, and their burning regimes favoured some species at the expense of others, but the changes they wrought were gradual and ecologically benign in comparison with what was to come.

The settlers who responded to Mitchell's reports cleared woodlands, introduced alien pasture species (not to mention sheep, cattle, horses, goats and rabbits), intensified grazing pressure and reduced fire frequency. Their descendants applied fertilisers, herbicides and trace elements, opening up even less fertile areas.

Now, native tussock grasslands have been largely displaced, their range contracting to rocky back paddocks, remote valleys on large properties, roadsides, rail reserves, vacant land, parks and neglected country cemeteries.

It would surprise many Australians today to know that the ecosystems that contain the most plant species and communities threatened with extinction are not the Wet Tropics or the eucalypt forests which still inspire such angst.

Of course grasslands and grassy woodlands aren't just about grasses. Native grassland refers to ecosystems in which the dominant plant species are perennial native grasses. Many other species within grasslands contribute to their biodiversity value, including tiny herbs and forbs that are sometimes difficult to see.

In flower, especially in morning and evening light, our native grasslands glow with a wonderfully subtle palette of delicate colours and wavy textures. I'm told that a single hectare of grassland in Gippsland contained some 320,000 flowering Chocolate Lilies, 570,000 flowering Scaly-buttons and 240,000 Common Everlastings.

It is a great shame that the most threatened, disturbed and pressured ecological communities in Australia today are in grassy landscapes.

Unfortunately, the same could be said of the human communities in those landscapes. We can never let ourselves forget that the environmental challenges we face ultimately come down to people—our knowledge, our commitment, our skills and our resources. These inform our daily choices, decisions and actions, which in turn shape our physical environment.

Many of the people managing native grasslands are under enormous economic pressures, generated by ever-declining terms of trade, collapsing land values and hence farm equity, and the need to generate additional income just to make ends meet, just to keep afloat.

This is placing great pressure on the land—pressure to intensify, to introduce improved pastures and fertiliser, to run more sheep, to shift from grazing to cropping, or to cultivate that unimproved back paddock that has always been a handy drought reserve or lambing and off-shears shelter.

Because so few of our original native grasslands and grassy woodlands remain in a relatively undisturbed condition, a few landholders now bear a disproportionate responsibility for the conservation of these ecosystems. The people whose land has been cleared, grazed, fertilised, cultivated and/or irrigated for many years do not have the same concerns. They do not bear a similar weight of community expectation that they will act altruistically for the greater public good.

Given that native grasslands have both conservation and production value, how can we ensure that both factors are valued and contribute to Australia's ecological and economic wealth? How can we achieve this vision of a healthy and productive environment where native grasslands and grassy woodlands are valued and celebrated for their contribution to conservation and to production?

I look forward to the outputs of later sessions today and tomorrow. These sessions will explore some of the real and potential ways that native grasslands can be retained and managed for productive purposes, in various combinations of agriculture, pastoralism, tourism and the emerging arena of 'ecosystem services'—where we start to value the contribution of natural systems to public goods such as climate amelioration, water quality and catchment hydrology.

I am heartened that a new generation of Australian land users is far more ecologically literate than our forebears, and working very hard to develop ways of making a living that maintain or enhance the natural resource base, rather than depleting or degrading it. Quite a few of these pioneers, including Biz and Lindsay Nicolson whom you will hear from this morning, are here today.

I am very pleased to note that, as well as the Nicolsons, there are many from the farming community in the audience today and that a number will be speaking at this conference—from local landholder Millie Nicholls to Charlie Litchfield from the Monaro in New South Wales.

The everyday responsibilities of managing native grasslands rest primarily with individual land users, local governments, and organisations such as Rural Lands Protection Boards, Cemetery Trusts and Rail Authorities. The primary legislative responsibility for natural resource management rests with the States and Territories. However, the Commonwealth, through Trust programs such as Bushcare, Endangered Species and the National Reserves System, is increasingly active in improving the overall framework within which native grasslands are managed.

One of the key elements of this framework is that of incentives—how to encourage and reward behaviour that is above and beyond the reasonable 'Duty of Care' that society has a right to expect of the individual landholder.

It is important to remember that more than ninety percent of this continent is outside formal conservation reserves. On the vast majority of this land, conservation of biodiversity is not the primary management objective. It must compete with other goals, such as making a living, supporting a family, farming, developing mineral resources, providing irrigation water, ensuring safe road conditions or entertaining tourists.

Some of these goals conflict with long term conservation of environmental values. It is often the case that the optimum, long-term biodiversity conservation option for a given land user is not the most profitable option, especially in the short-term. Getting the best outcome for society as a whole may incur a real cost for the individual land user, municipality or company.

Native grasslands on private land are often in this category, particularly with the current depressed wool market. Jim Crosthwaite's Bushcare-funded research shows clearly that when we ask farmers not to cultivate that back paddock of tussocks because of its conservation value, we are often asking them to forego real short-term increases in farm income, income that could be critical for the immediate viability of the farm.

In such instances, there can be a case for public investment to ensure that a small number of individuals are not bearing an unreasonable share of the cost of changing to more sustainable land uses in the interests of society as a whole.

I believe there is huge scope to better match public expectations for conservation on private land with more attractive types of assistance for private land managers to deliver those conservation outcomes.

Bushcare, along with the Land and Water Resources Research and Development Corporation, has funded cutting-edge research to develop a rigorous intellectual framework within which incentive-based instruments can be applied. We are now applying these incentives, with different incentives in different contexts—from up-front grants to stewardship payments, differential rating systems, assistance with planning, and information and advice, right through to voluntary acquisition.

Investment in our understanding of native grass species, through the *Flora of Australia* volume on grasses, is fundamental to the improved management of grasslands and grassy woodlands. We have to know which species we are dealing with. As part of this contribution to our knowledge of grass species, I am launching today a series of posters that will assist land users and community groups to recognise some of our most common native (and introduced) grass species.

For those of you who are unfamiliar with the *Flora of Australia* series prepared by the Australian Biological Resources Study (it must be one of our best-kept scientific secrets) I thoroughly commend it to you. Bushcare has also funded the volume on Acacias.

Our work on incentives, taxonomy and research is complemented by direct investment through the Trust both in on-ground measures to conserve and enhance native grasslands, and in capacity-building to boost the ability of others to do more.

Most of you here will be very familiar with the work of Tim Barlow, our grassy ecosystems networker in south-eastern Australia, who has done much to find, link and help landholders with outstanding native grasslands, and of course in helping us to organise this conference. Projects like Tim's make a big difference in keeping an issue like grasslands bubbling in a constructive way.

Bushcare has also contributed to the management of grasslands in South Australia through the World Wide Fund for Nature who are working with local landholders here in the Clare Valley to protect and manage the local grassland sites. You will find out more about this project later.

On the production side, Bushcare is contributing to the development of best-practice management guidelines for the incorporation of biodiversity into sustainable grazing systems in Northern Australia, in partnership with Meat and Livestock Australia.

A number of other important grassland projects have been assisted through the Natural Heritage Trust.

In 1997-98, the Commonwealth approved funding through the National Reserves System for the purchase of Naringaningalook, a property supporting endangered grassland communities in the high priority Victorian Volcanic Plain bioregion. The property was covenanted and is managed by the Trust for Nature (Victoria). This was the first time that the Commonwealth had assisted in the acquisition of a property to be managed as a private protected area.

Since then, the Commonwealth has assisted in the purchase of a number of important grassland sites. The South Australian Minister for the Environment and Heritage, the Hon. Dorothy Kotz, has already told you about the recently purchased Mt Cone Grassland Reserve. More recently, the Commonwealth has been involved in the purchase of Albinia Downs in Central Queensland, which includes about 7000 hectares of native Mitchell Grass Downs.

These purchases demonstrate how conservation partnerships between the Commonwealth, States and Non-Government Organisations can work for everyone's benefit.

While acquisition of land is an integral part of conserving native vegetation, it is neither feasible nor desirable to rely on land acquisition alone for the protection of native vegetation.

I am now in the middle of going through Natural Heritage Trust applications for the current round of funding and I am tremendously impressed with the quality of the proposals this year.

I still feel, however, that not enough is being done to protect our native grasslands and grassy woodlands. That is why I am announcing today a 3 year, 1.5 million dollar Bushcare devolved grant to the World Wide Fund for Nature, for the conservation of temperate grassy ecosystems in south-eastern Australia.

This project has received considerable support from State and Territory conservation agencies. It will build on the results of the Natural Heritage Trust-funded project 'Best Practice Conservation of Temperate Native Grasslands', which you will be hearing more about from James Ross later today, to put the lessons of that project into practice on a much larger scale.

Funding through the devolved grant will be directed to five main areas:

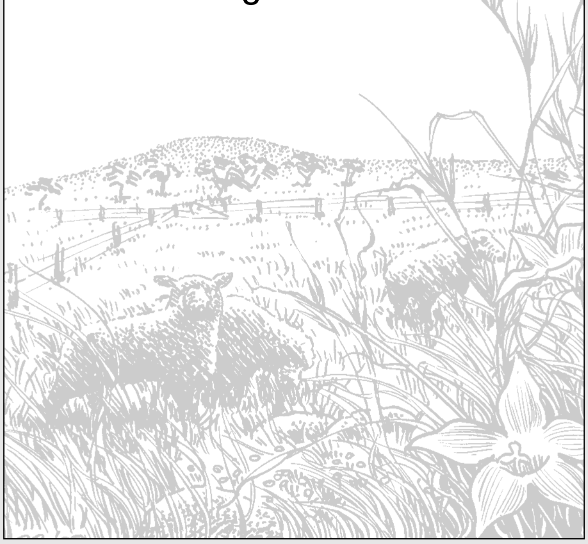
- increasing the number of covenants and land management agreements for nature conservation in grassy landscapes on private land;
- increasing the number of land management agreements with public authorities who are managing native grasslands;
- improving grassy ecosystem management techniques;
- increasing community involvement in grassy ecosystem management; and
- increasing and disseminating knowledge about grassland and grassy woodland remnants, especially those on private land.

Finally, in welcoming you to this conference and encouraging your full participation, I would like to throw you a challenge—a challenge that I think we need to deal with as a community over the next few years.

Native grasslands and grassy woodlands have been the Cinderella of conservation efforts to date. It is now time to recognise the value of native grasslands for both production and conservation, to celebrate their beauty and diversity, and to take this opportunity to enhance our natural heritage through their protection and sustainable use.

# Session 1

## Setting the Scene



# Farming with nature (1)

Lindsay Nicolson

'Bonneys Plains', Conara TAS 7211
Bonneys.Plains@tassie.net.au

Balancing nature conservation with production on a traditional grazing enterprise is an act that involves juggling finances, viability, family and time. We present a case study of past farming practices to the year 2000 and the effect it has had on fauna and flora at Bonneys Plains (2300 ha). A range of practices have been implemented to accommodate nature into the farming equation and actions taken to address simplification of the landscape and the consequent imbalance of native fauna.

The challenge of the Midlands Bushweb project is to take the experiences of implementing nature conservation from a farm scale to a catchment scale, incorporating national, state, local and farm priorities. However, these priorities differ and are therefore difficult to implement. The difficulty arises because as a nation we do not have a strong and united vision for our rural landscape. Incentives to incorporate nature conservation will be put in place over the life of this three year project, but more importantly we will outline incentives that are needed to realise a new vision for rural Australia through to the year 3000.

## A Question of Balance

The notion of the topic 'Farming with Nature' is a romantic one. It can be satisfying and at times it can be very frustrating. There are many forces and considerations that influence a farming enterprise, all impacting on the business.

Foremost, we have to consider our family—to balance our time between our family, quality of life, and that attributed to our work commitments.

We need to consider our land—balancing production with the land's ability to produce.

We have to build and work with a team of people within the business—people who like to see the books balance.

We must consider the Bank Manager—whose idea of sustainability is generally more cash in than cash out. Not much interest in nature conservation.

Then there is the Accountant—whose idea of sustainability is cash in our pocket, cash in his pocket, and an absolute minimum to the Tax Office. Not much interest in nature conservation.

There are many others, all gently pulling in different directions. Generally, with a bit of effort and thought, we can satisfy most of these most of the time, but by far the most difficult has been trying to balance the massive imbalance between the farming environment and the land's other values, namely its natural environment.

Our continued fetish to replace Australia with Europe has made maintaining and managing what is left of our indigenous landscape and its flora and fauna very difficult.

Our 2300 ha property, 'Bonneys Plains' in Tasmania's Northern Midlands, has a productive balance of roughly 25% arable land and 75% natural grassland and grassy woodland. The 25% has, at some time, all been cultivated and replaced with introduced grasses. These have significantly increased production, and similarly they have made a significant contribution to increasing farm running costs through their high maintenance and escalating replacement costs. They do provide more feed, not only for domestic livestock, but also for some native herbivores, which have thrived since their introduction, in some instances at the expense of other native species. The two main offenders we contend with are Bennetts Wallaby and the Brushtail Possum, both keen competitors for available feed.

The new grasses have proved to be an exceptional food resource for some of our subterranean native species, like the corbie and cockchafer grubs.

These grubs have evolved and lived in harmony with native grasslands, but they can create absolute havoc with many of the introduced, so-called improved and permanent pasture grasses.

I'm not sure how you can improve on, or be more permanent than, a pasture that has managed to exist as a stable plant community for a couple of centuries despite all the abuse we have thrown at them. One hundred and fifty years of grazing by domestic livestock has had a catastrophic impact on the natural woody flora, with an almost complete depletion of the understorey layer. What remains is being reduced to small pockets that are virtually inaccessible to livestock and wildlife. Along with the loss of small plants went many small birds, small mammals and marsupials, all being replaced by larger more aggressive species—some introduced, some native. In the case of animals, the replacement species have been a mixture of domestic, feral (fallow deer) and native. In the case of the flora, it has been introduced species, many of which are now recognised weeds—either noxious or just plain obnoxious.

## Revegetation/ Regeneration

The last 25 years has seen the disappearance of practically all the remaining Eucalypts through the arable part of the farm, a process that started during the mid 1960s and has progressed to a stage where those remaining could be counted on one hand. It has been an insidious process, virtually eliminating two of the three lowland species, the Manna Gum *(Eucalyptus viminalis)* and Swamp Gum *(E. ovata)*. We're now left with just a handful of Cabbage Gums *(E. pauciflora)*.

Despite isolated research attempts to understand the phenomena, we've been powerless to stop its progress. There is, however, a distinct relationship between the rate of tree death and the extent of human interference. As a reaction, we commenced a revegetation program in 1984. For one reason or another, the failures outnumber the successes. The pressure from wallabies browsing young seedlings, fallow deer bashing the life out of anything that reaches a metre or so in height, and possums doing their best to defoliate those trees that do manage to get away once they are strong enough to support a possum's weight. Caterpillars, beetles and other defoliators proceed unchecked, there being precious few small insectivorous birds to clean up. These are all indications of the extent of the ecological change.

Persistance does pay off, however. We have had some wins and its encouraging to see some of the earlier planting now starting to perform a more natural function as homes for some of the smaller marsupials and ground-nesting birds, and providing habitat for an increasing number of smaller birds. Buffalo Brook, a permanent stream running through the property, became an active erosion ditch after it changed course following severe flooding in 1929. A program to exclude livestock, which commenced in 1986, has transformed the 5 km section back to the condition it probably would have been in before European settlement. We've listed in excess of 45 different native trees and shrubs that have re-established themselves in this reserve, and we're still coming across one or two new species each year. There is also an abundance of small birds that have taken up residence. This is an area that previously supported an occasional Silver Wattle, a couple of Prickly Box, and no birdlife. The important thing to realise is that the only variable has been the absence of domestic livestock. No planting or seeding has taken place.

## Native Grasslands.

Our other area of concern and interest is our native grasslands. As mentioned earlier, they occupy about 75% of the property. They exist on the steeper slopes and vary from open grasslands to grassy woodlands of varying density. Regrettably, the last of the plains, or lowland grasslands, went under the plough in 1974. Traditionally they were set stocked with dry sheep and cattle, usually for a period of seven or eight months from late summer until calving and shearing the following spring. This allowed for extended rest, which incorporated the major growth and flowering period. Changing seasonal patterns over the past couple of decades often necessitated the stock being returned earlier than normal, not allowing them to fulfil their natural cycle. We decided to remove cattle altogether because their sheer size and weight was having a negative impact, most noticeably by bogging natural waterways and springs. They were also responsible for much of the browsing on the remaining woody native vegetation.

With just sheep, we moved to a full 12-month, high density rotation. In reflection, I believe this system could be the most beneficial for a pure grassland. It is designed to favour grasses and it wasn't until we commenced using the rotation that it became blatantly apparent that we were managing for two totally different values: the grassland and a grassy woodland.

The rotational system definitely didn't favour the remnants of the understorey layer. With the high stock density we found sheep using country they had never gone into before. Practically all the subdivisions had pockets of seemingly intact woodland, but these very quickly came under threat. The overall stocking rate hadn't altered, but the high stock density during the grazing period became a problem. We had a couple of other misgivings about this system. The clay–loam soils became increasingly hard under foot, raising doubt about their ability to take up available moisture, further contributing to what seems to be an ever-drying environment. It appears that 150 years of stocking has altered the plant diversity substantially. There's ample evidence that the area was much damper, with small remnants of plants belonging to a wetter environment.

Those observations, together with the time commitment moving sheep in this country—sometimes taking four or five hours to gather and move a mob of sheep, has been the catalyst for us to revert back to the extensive rest/set stocking regime. The difference is that we now have retired nearly half of our bush from running domestic livestock all together. We have just under 800 ha (or 30% of the farm) in permanent reserves, in an attempt to encourage the return of some of the smaller woody plants and small animals to encourage some regeneration of eucalypts and other canopy species. We had been rapidly regressing to a single-aged woodland with all regeneration being demolished by livestock. The country is still grazed, but now just by native animals. The compromise is that the larger herbivores are encouraged to keep out of the valley floor to allow for greater success with our revegetation, and to decrease some of the competition for stock feed. This has necessitated a 10 km game fence being constructed between the two zones. Three km have so far been completed.

Since leaving school, I've witnessed the total disappearance of several shrub species and the decline of many others from our landscape, many of these now exist in small isolated patches or in some cases single plant remnants. Without help, these too would soon be part of a new common denominator. We are no longer prepared to accept a level of declining diversity.

Bonneys Plains has seen human intervention have an effect on: life in the air, with changes in structure of bird life; life above the ground, with the changes in all strata of woody vegetation; life on the ground, with massive changes to our grasslands and the life they support; life below the ground, with changes to the invertebrates; and life in our waterways, with changes to the quality of our water and the diversity of its inhabitants.

It should be a critical part of any farm plan to develop strong, sincere landscape goals detailing how we would like to respect and enhance our farms' natural values into the future.

# Farming with nature (2)

Biz Nicolson

'Bonneys Plains', Conara TAS 7211
Bonneys.Plains@tassie.net.au

If I were to chain myself to an old growth Huon Pine tree in protest against the destruction of an ancient forest that has existed for thousands of years, it would be considered an act of heroism, a woman trying to stop an act of vandalism that would cause an outcry nationally and internationally.

If, however, I were to chain myself to a piece of Kangaroo Grass in protest against the destruction of an ancient grassland that has existed for thousands of years, it would be considered an act of an eccentric woman in desperate need of medical attention. Although the destruction of our grasslands continues daily, it does not cause an outcry. As a nation, we are not passionate about our grasslands.

Lindsay and I are very honoured to be working with the Bushweb project in the Northern Midlands of Tasmania, a beautiful vast grassy landscape. This project is implementing the vegetation plan for the Macquarie/South Esk Catchment. The Bushweb project offers monetary incentives for protection of remnants and revegetation. We have 10 year management agreements for areas reserved, covenants, a local government reward system, and tailor-made education packages.

And at the end of the 3 year project, what will we have achieved? We will have achieved many more green dots and lines on the map, but unfortunately the largest green areas on the map will be grazed harder, logged or ploughed. While we have been working on this project we have concluded that sustainable agriculture is built on 3 pillars—social progress, economic growth and ecological balance, and we cannot achieve one without the other. So let us look at these 3 pillars in the context of the Bushweb project.

Firstly, social progress. In our community, banks, schools, hospitals and businesses have closed, youth are leaving, partners are taking their children to town for better opportunities but not returning, and farms are now generally owner-operated with a very tired and disillusioned operator at that.

We could cope with the decline in social progress if we had economic growth, the second pillar.

In 1951, one prime fat lamb brought 6 pounds. This paid the wages of 1 man for 1 week. In 1999, one prime fat lamb pays the wages of one person for two hours. In 1956, 2 bales of wool paid for one new 5 tonne truck. In 1999, 90 bales of wool will buy that same new truck.

So how do we react to this situation? We blame business, the banks, the government and the level playing field concept, and yet the prices keep dropping and we push our land and ourselves harder in the hope of making ends meet, but like our irrigators we run round and round in ever decreasing circles.

So how have we survived for the last 50 years in farming?

- we have cut back on expenses until we can't cut back any more;
- we have diversified into numerous enterprises with less labour;
- we have increased production using new beaut grasses, clovers and fertilisers advocated by globe trotting agronomists;
- we have improved the genetics of our stock and dramatically increased the numbers;
- and now irrigation is going to be our salvation and the plough will deal the final blow to our lowland grasslands.

So what about the third pillar, ecological balance?

In our catchment:

- small birds and mammals are leaving and larger mammals are increasing;
- the understorey shrubby layer is disappearing;
- trees are dying;
- reliable creeks and springs are drying up;
- insects are defoliating the trees; and
- seed is insect damaged, has low viability or is not setting seed at all.

We are told our landscape is beyond repair. Our landscape has changed too much. Plant radiata pines, they are the only thing that will survive. We know better, but if we do not have a strong united vision for our grassy landscapes then it will become part of someone else's vision, and it will probably be salted pine trees.

But farming businesses alone cannot address sustainable development, and the Commonwealth, State, local community and individual farmers all need to pull in the same direction. For example, it is not enough for the Commonwealth to declare a plant species threatened and in need of protection if the State Government declares the need for an irrigation scheme that will flood those same rare plants, but will benefit the local farming community. And the farmer with the threatened plants, well, whatever they do they will end up the bad guy.

So how is our grassy landscape going to survive to the year 3000? Presently, those who have preserved their grassy landscapes do not receive any financial incentive and programs like Bushweb really have nothing to offer. This is because these areas produce millions of dollars of produce annually and all Bushweb can offer is a fence. We need a new approach and we need to focus on our opportunities rather than our problems.

So let us look at our balance sheet as we enter the year 2000:

- we have vast areas of land;
- we have, thanks to Landcare, an amazing turnaround in attitude;
- we have a willingness to embrace conservation issues;
- we have some excellent grassy remnants supporting a unique and diverse range of fauna and flora;
- we have a broad knowledge base and a large amount of collective data; and
- we have elders in our community who can recall fauna, flora and water details.

What land managers need is a financial incentive that is far greater and far more powerful than the present incentive to clear for higher value crops or push the landscape harder with grazing; an incentive that inspires land managers to revegetate or protect the grassy landscapes without subsidy; an incentive that will ensure that our grassy landscapes survive without compromise to the third millennium without containment in biological zoos; an incentive that allows our native fauna to survive in its natural habitat without threat; an incentive that provides a regular and reasonable income for farmers that enables them to provide employment opportunities for rural communities, so they too can thrive.

### Sound unattainable?

I believe we can achieve this vision, but we all need to commit to achieving it—an approach proved possible by the USA, which decided to put a man on the moon when no-one knew how. In our lifetime, we have seen televisions, computers, and the internet transform our lives—the result of vision and doing the seemingly impossible.

But perhaps there are three major opportunities that we can draw from our balance sheet right now and head us in this direction.

Australia, with its vast areas of land, has a unique opportunity to become the lungs of the world. Business is ready and willing to embrace their responsibilities and invest in carbon trading, and billions of overseas investment dollars are going begging right now.

### Sound impossible?

The Emission Trading Company doesn't think so and would like to talk to our farmers in the Northern Midlands.

We can revegetate with monocultures, but we know monocultures are not sustainable and Australia has learnt some bitter lessons. We now have a broader knowledge base and expertise. We can do better than this.

Our vision, therefore, is for Australia to become the ecological lungs of the world. We can plant trees and incorporate understorey necessary to support our fauna. Presently, wildlife has no measurable value and is in fact seen to be in competition with farmers economic viability. It's out there, somewhere, and we hope it's doing okay. But what if our farmers who measure their carrying capacity in dry sheep equivalents were now measuring their carrying capacity in dry bandicoot equivalents? And what if we showed our bank managers our production figures in diversity of fauna? And what if we showed our accountant our income in carbon and wildlife credits?

Sound ridiculous?

The World Business Council for Sustainable Development doesn't think so. This is an organisation based in Switzerland that represents a coalition of some 125 leading international companies that are united by a shared commitment to the environment and sustainable development. Many of these companies have incomes higher than the Gross Domestic Product (GDP) of many nations. They would like to enter into dialogue with us and with the Australian Government.

But Australians have a problem with locking land up for conservation. So what are we locking up? We are locking up our future, we are locking up our potential and we are locking up our competitive advantage. We have been so busy producing commodities that everyone else in the world is producing and blaming banks, governments and level playing fields that we have forgotten to look in our own backyard and capitalise on our competitive advantage. Our competitive advantage is in our understorey, the scrub, the stuff we have burnt, ploughed, grazed and bulldozed.

Three years ago, Lindsay and I had the opportunity to study the economic opportunities of our understorey plants. Our 5,500 acres of grasslands at Bonneys Plains supports only one family, but it has enormous potential. After our study tour we established Taz Wild Plants to pursue these opportunities with the aim of producing our income from 35 acres. We have found our landscape has so much opportunity that, in 3 years, the same income is now derived from 1/4 acre. The response has been overwhelming:

- yes, we will take as much seed as you can produce;
- yes, that plant can be used for ketchup flavouring and that bulb and that fruit are edible and saleable;
- yes, these plants are excellent for foliage;
- yes, the Japanese want those sedges for floral arrangements;
- yes, we will take as many bunches of flowers as you can produce;
- yes, that form is highly desirable for the export market and you should take out PVR immediately;
- yes, that plant is very palatable and has a higher stock feed value than lucerne; and so the opportunities go on.

Landcare and Natural Heritage Trust funding have turned the rudder of opinion from our course of environmental destruction. To save our grassy landscapes, it is time for us to be passionate and committed, and for our farming needs to reflect our Australian landscape. We need to all work together and grab hold of that rudder of opportunity and give it a jolly good yank.

# Biodiversity does matter

Denis A. Saunders

CSIRO Wildlife and Ecology
GPO Box 284, Canberra ACT 2601
denis.saunders@dwe.csiro.au

---

Biodiversity is defined as the variety of all life forms and their patterns in space—the different plants, animals and micro-organisms, the genes they contain and the ecosystems of which they form part. There are three interactive levels of biodiversity; diversity at the genetic, the species, and the ecosystem levels. The term covers a large array of ecological complexity and is poorly understood.

To most people, biodiversity is taken to mean species diversity. This erroneous interpretation leads to biodiversity being seen in a restricted way. For example, in agricultural landscapes, many people assume that biodiversity is found only on conservation reserves, on uncleared agricultural land, or in remnant patches of bush on farming land. Agriculture is totally dependent on ecosystem processes and functions such as soil formation, nutrient cycling, maintenance of hydrological cycles, pollination of crops, etc. These processes and functions are all driven by interactions between elements of biodiversity. The narrow species-focussed view of biodiversity gives rise to the notion that landscapes can be compartmentalised and that protection of remnant native vegetation is therefore the primary action required for the conservation of biodiversity. This attitude does not take into account the majority of biodiversity, and is leading to continuing loss of its essential elements.

Agricultural landscapes must be managed in an integrated way, rather than following the form of ecological apartheid that currently constitutes landscape management. Future landscapes must be managed for sustainability; that is, to ensure that the use and management of our natural resource capital does not reduce its capacity to meet society's future environmental, social and economic needs.

---

*Keywords: Biodiversity, sustainability, vision*

## Biodiversity

Biodiversity is the variety of all life forms and their patterns in space—the different plants, animals and micro-organisms, the genes they contain and the ecosystems of which they form part. Importantly, biodiversity covers not only the genes and the life forms themselves, but also includes the interactions between them and the environment. Thus there are three interactive levels of biodiversity; diversity at the genetic, the species, and the ecosystem levels. The term therefore covers a large array of ecological complexity.

Unfortunately, most people misunderstand the term and it is usually understood to mean species diversity. In fact, it is sometimes even more narrowly misinterpreted to cover just the conservation of rare or endangered species, usually the conspicuous flowering plants or vertebrates. This erroneous interpretation leads to biodiversity being seen in an extremely restricted way. For example, in agricultural landscapes, many people assume that biodiversity is found only on conservation reserves, on uncleared agricultural land, or in remnant patches of bush on farming land, that may or may not be fenced-off.

Of course, this view ignores the fact that agriculture is an ecological enterprise. Agriculture is totally dependent on ecosystem processes and functions such as soil formation, nutrient cycling, maintenance of hydrological cycles, pollination of crops, etc. These processes and functions are all driven by interactions between elements of biodiversity. The narrow species-focussed view of biodiversity gives rise to the notion that landscapes can be compartmentalised, and that protection of remnant native vegetation is therefore the primary action required for the conservation of biodiversity. This approach is basically ecological apartheid and is typical of much of our present natural resource management. This attitude does not take into account the majority of biodiversity, and it is leading to continuing loss of its essential elements.

## Why should we worry about biodiversity?

Conservation and maintenance of biodiversity are important for four reasons: life support; economics; aesthetics and culture; and ethics. From an anthropocentric viewpoint, our survival depends on biodiversity as many of its elements provide the critical life support systems that make human life possible. These are the healthy, functioning ecosystems that maintain the atmosphere (including the air we breathe), regulate the climate, produce fresh water, form soils, cycle nutrients, and dispose of wastes. Biodiversity also provides us with great economic returns, for example in the provision of food and fibre, medicines, control of pest organisms, building materials and crop pollination. It is an essential element of tourism, an area of enterprise that is rapidly increasing in economic importance. Many people obtain cultural identity, spiritual enrichment and recreational activities from elements of biodiversity. Much of the Australian 'sense of place' comes directly from biodiversity. This is not only of fundamental importance to Aboriginal and Torres Strait Islander peoples, but is also true of most rural people. Think of what I term our 'icon rural scenes', which were captured so vividly by painters such as Hans Heysen. Our unique native vegetation with its associated native fauna is what gives Australia its distinctive character and colouring. For example, the mountains or hills on the horizons of many Australian landscapes get their distinctive blue colouring from light being refracted through the volatile oils given off by the eucalypt. At a level that is not trivial to the culture of some people, many of our sporting teams are named after components of our biodiversity; even the green and gold of our Olympic uniforms are derived from the predominant colours of elements of our flora. Conservation and maintenance of biodiversity are also important for ethical and inter-generational equity reasons in that no generation has the right to appropriate Earth's resources solely for their own benefit. This is one of the major platforms behind the need to develop enterprises that are ecologically sustainable. It is also an important element of the desire of many farmers and graziers to leave the land in 'better condition than when they started managing it'.

## Status of biodiversity

Like most other countries, Australia's record for managing its biodiversity is poor. We have been taking a free ride on the back of our biodiversity and we are still mining it. The 1996 Australian State of the Environment Report stated that loss of biodiversity:

*'is perhaps our most serious environmental problem. Whether we look at wetlands or saltmarshes, mangroves or bushland, inland creeks or estuaries, the same story emerges. In many cases, the destruction of habitat, the major cause of biodiversity loss, is continuing at an alarming rate.'*

It has been estimated that there are more than one million species living in or around Australia. However, less than 15% of these have been scientifically described. It is safe to say that we have no idea what was present in or around the continent in the late 1770s when the major extensive and intensive human-induced changes to the Australian environment began. We don't have a very much better idea of what is present now. We know the identities of most of the vertebrates (mammals, birds, reptiles and amphibians). We know much less about the plants, and we know only a small percentage of the invertebrates, including the thousands of tiny organisms in our soils and waters. Those plant and animal groups we do have information on are all showing alarming declining trends.

## Why is biodiversity important to agriculture?

Every farmer knows that maintenance of soil fertility and condition is the basis of all agriculture. Farmers also know that it is expensive to keep applying fertilisers and soil ameliorants (such as lime and gypsum), and that problems of soil acidification, salinisation, compaction, loss of structure (and therefore water infiltration) and soil loss (erosion) are serious problems that greatly reduce profitability. A common reason for these various forms of soil degradation is loss of soil biodiversity—the loss of 'free' ecosystem services that biodiversity provides.

Because it is minute, many people do not realise the wealth of biodiversity that exists in soil. In fact, the majority of biodiversity in agricultural landscapes occurs in the soil. In every hectare of soil in temperate regions there are about:

- 20,000 kg of microscopic organisms (such as bacteria, fungi, etc);
- 50 kg of microfauna (organisms less than 2mm in length, such as nematodes and protozoa);
- 20 kg of slightly larger organisms (2-10 mm, such as microarthropods); and
- 900 kg of organisms greater than 10 mm (such as earthworms and termites).

This mass of living organisms is as much or greater than the mass of most of the agricultural products standing on the surface of that same area of land. For example, a crop of wheat in eastern Australia that produces 5,000kg/ha of grain may have had a total biomass before harvesting of about 15,000 kg/ha compared with around 21,000 kg of soil organisms/ha.

The millions of organisms making up this huge mass of thousands of different species don't just sit quietly in the soil. They are highly active, burrowing, moving soil around, ingesting it and mixing it with their intestinal juices before defecating it, consuming dead roots and litter, absorbing hard-to-get-at-phosphates (mycorrhizal fungi do this job excellently), and performing a host of other soil forming processes. Soil pores bigger than 2 mm in diameter are all biologically determined, and these pores play a major role in the water infiltration properties of soils, and in determining such things as bulk density and water-logging. Without the soil biota, nitrogen would not be mineralised, and under reduced soil biodiversity soil fertility and structure decline rapidly and markedly.

Native species also play a major role in the control of agricultural pests. Pesticide resistance is an increasingly worrying problem and in south-east Asia, for example, there is a move from chemical to biological control; not because of the costs of pesticides (which are high), but because it is the only successful way to control a number of insect pests.

The issue of biodiversity services needs to be borne in mind when making decisions on land use. For example, a patch of remnant vegetation may provide more than aesthetics, shade and shelter. It is removing carbon dioxide, producing oxygen, using water, and may have roles in controlling water tables, and the movements of wind and water over the surface of the land. At present, these services tend not to be included in the cost accounting for agricultural production.

## Biodiversity and sustainability

Sustainability means many things to many people, but in my view sustainability is about the need to ensure that the use and management of our natural resource capital do not reduce its capacity to meet society's future environmental, social and economic needs. The order of the wording is important because economics drives decisions made at present and we have already committed much long-term environmental damage for short-term economic gains. We will continue to do so until we acknowledge that economics must operate entirely within environmental constraints, and develop an accounting system that operates within those constraints. I believe that in the long-term it will be the adverse environmental changes that will create most problems for society.

Sustainability means the capacity of the management area to provide for the continued existence of its present biota. It needs to be strongly pointed out that humans are an essential element of this biota—not something unnatural and apart from it, which is how we regard ourselves at the moment. Sustainability also means that as a matter of intergenerational equity, the management area must have the capacity to provide future generations of the biota with the same options the current generation enjoys. By any measure we care to name, using this description of sustainability, we are far from sustainable at present.

A quick roll call of the environmental issues that have developed, or are developing, in our agricultural landscapes illustrates this point starkly. I am not dwelling on this point to emphasise what we have already done to our environment, but rather to illustrate the many problems we have to address in our search for sustainability. While the fallout from these environmental issues is providing powerful incentives for change, I question whether this message is getting through to all sections of the Australian community. I am prepared to bet that everyone at this conference accepts the need to change the way we now operate, but there are many outside this room who do not, particularly among the 85% of Australians who live in our cities. We need to be clear that the changes we are seeking must involve changes in attitudes and behaviours that will lead to changes in land-use practices.

What are the problems we have to address in our search for sustainability? The first are environmental. Much of agricultural Australia has been cleared of native vegetation. Clearing is a highly selective process, being concentrated on the flatter, more fertile soils. As a result, the vegetation types associated with those soils are to all intents and purposes extinct. Our native grassy woodlands fall into this category. Much of the remaining vegetation is declining in quality and losing species, and will continue to do so.

In addition, processes threatening the sustainability of our agricultural areas continue, in some cases at alarming rates. Clearing or degradation of remnant vegetation is continuing. In some cases, the decline is as a result of changed ecological processes; that is, processes that we have set in motion and will be changing the landscape for decades, if not centuries. Fragmentation of remnant vegetation is a consequence of these processes. Overgrazing by domestic livestock, feral animals and some native species is causing the decline in native vegetation and is an example of one of these processes.

Altered hydrological regimes, changing surface flows and drainage, and changes in infiltration rates to groundwater are obvious examples of changed ecological processes. All of these have resulted from broad-scale removal of native vegetation. In some places groundwater is rising by up to 0.4 m per year, and as it hits the root zone of plants it is resulting in extensive salinisation with the potential to affect vast areas of productive agricultural land and remnant vegetation.

Invasions by weeds, depredations by feral animals and infections by pathogens such as *Phytophthora* are all changing species compositions and leading to further degradation of native vegetation and associated animal communities. In addition to these threats, extractions from remnant vegetation for firewood, eucalyptus oil, timber, and native plants, and cleaning up of what is termed litter or rubbish, such as dead trees or hollow logs on the ground, are compounding the loss of conservation values. We are also seeing the accelerated loss of that wonderful icon of rural Australia, the stately old gum tree standing proudly in the paddock. These are now the 'living dead' and it is only a matter of time before they disappear, changing the aesthetic nature of our rural landscapes forever.

Of course, it is not only remnant vegetation and its associated animal communities that are being degraded. Pollution, including that from herbicides and pesticides, is adversely affecting land and water. Agricultural productivity is being affected by soil acidification and soil structure decline, in addition to soil salinity. And this list is not exhaustive.

Social problems are a consequence of many of these environmental problems. The average age of farmers is increasing rapidly and the rate of intergenerational transfer of farm ownership is declining. In rural areas all over the country, the young see the writing on the wall and are opting out of rural landscapes in large numbers. In some cases, they are opting out in rather more terminal ways than merely moving to our cities. Rural businesses are failing and reducing the diversity of rural society. Rural towns are physically decaying. This is manifest in many towns in the damage to the infrastructure caused by rising salinity.

Then there are economic problems, many of which are entwined in the issues raised earlier. Many small farmers are not generating sufficient income to be considered viable. By small farmers I do not mean those who are vertically challenged, but rather those who are area challenged. Many farmers have to resort to off-farm income to survive, but these opportunities are limited.

There is already a decline in land-use for traditional agricultural enterprises and a growth in land-use for other industries. This will continue. There is no doubt that the wonderful national icon, the rural Aussie battler, is an endangered species. However, with the growth of tourism as a major industry, innovative programs for the maintenance of the Aussie battler may become important.

Our path to a sustainable future will not be easy as all of these issues must be dealt with. Sustainability can only be achieved when we have an environment that supports the continued existence of all its component parts. To do this we must realise that the economy is a subset of the environment and not vice versa, and that our social systems must also work with the environment, not against it. At present, I don't believe that we have an accepted collective vision of what we want our landscapes to look like and how we want them to function. One major consequence of this lack of vision is that there is no integrated approach to planning and acting for the future. Using salinity as an example, our actions do not match the rhetoric on the problem and the stated need for extensive revegetation, either at the state or national levels. Failure to develop and implement a collective vision will see us continue to tinker on the fringes of the problem and see future generations facing biotically impoverished landscapes with extensive areas needing remediation at vast cost.

In my opinion, and that of others, we need to develop a vision of what we want our rural landscapes to look like, how we want them to function ecologically, and what we want them to support in future. In doing so we should have some time frame in mind. Remember that it has taken us 200 years or so to get to our current situation and it is going to take us decades, if not centuries, to achieve the landscapes of our vision. I pose 150 years as one time frame to work within. If we want to add ecological function into our landscapes, we need to think in terms of the cycling times of those functions. For example, it may take 10 years or so to revegetate over sufficient areas to draw down watertables. However, it will take about 150 years for a eucalypt to be large enough to evolve a hollow large enough to provide a nest for a Black Cockatoo. Bear in mind that this is only the first stage of the cycling of nest hollows.

Having developed the vision of our landscape of the future we then need to plan our route to achieving it and implement the plan. This will involve defining the environmental, social and economic problems that stand in our way and then designing a reconstruction plan to implement. These are not trivial tasks and many people need to be involved in developing the vision, designing the plan and in implementation. We should not deny the magnitude of the task. Nor should we shirk from the responsibility of its implementation. Those involved in managing the land must be major drivers in this process.

What management systems do we need to develop to ensure sustainability? How do we go about setting them up? It is worth bearing in mind that we will have to adjust our management over time in relation to feedback we obtain by monitoring our management as we go. This is adaptive management and in carrying out our management we are using it as an experiment to help us refine our approach to sustainability. If we are to be successful in management we have to manage the landscape as a whole rather than the piecemeal approach to management employed at present. As I mentioned earlier, most of our present management is based on ecological apartheid; that is, on an extremely compartmentalised basis.

## How do we get where we want to go?

I will finish be putting forward my 10 point plan to guide development of a path towards a sustainable future.

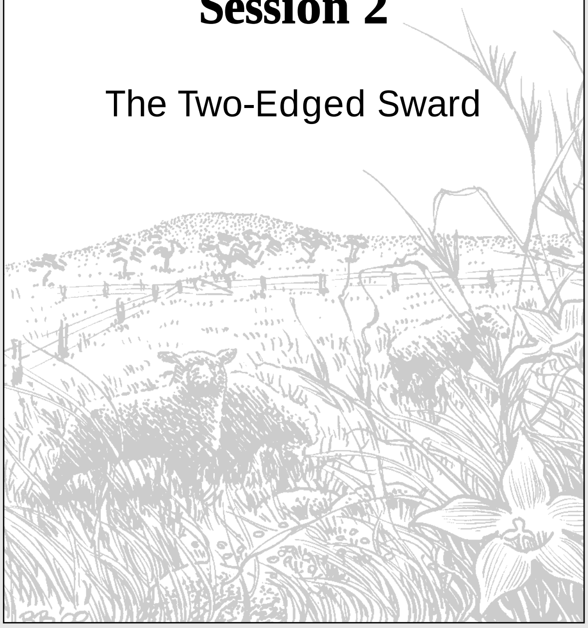
1. Develop a vision of the landscapes of the future and how they should function ecologically, socially and economically.
2. Define the environmental, social, institutional and economic problems that need to be addressed to achieve that sustainable future.
3. Establish what was present in the landscape before development and what is there now.
4. Establish what skeleton is available to build the future landscape upon.
5. Retain, protect and manage all remnant vegetation to prevent further loss of dependent biota.
6. Design a reconstruction plan based on an ecological zoning.
7. Establish goals, structures (or frameworks) and timelines for developing the landscape of the future.
8. Act on the plan, using best local knowledge, science and experience available.
9. Monitor progress and record results; adapt management accordingly.
10. Lead by example and communicate widely.

## Acknowledgement

I am grateful to Drs Sue Briggs and Robert Lambeck for constructive criticism on this paper.

# Session 2

## The Two-Edged Sward



# Native grasslands – a South Australian perspective

Millie Nicholls

World Wide Fund for Nature Extension Officer
'North Marola', Clare SA 5453
marola@senet.com.au

It is well known that the Mid-North of SA was largely native grassland at the time of white settlement, but it is not so well known that there are large areas of both grassland and grassy woodland remaining on the steeper slopes of the series of ranges that run through the Mid-North. These areas—estimated to be about 500,000 hectares—are utilised as hills grazing and are not considered to be very productive. My family owns a farm that has a large area of degraded grassy woodland, and our challenge is to run an economically viable farm utilising this area of degraded native grasses.

The predominant grasses are Spear Grasses, Wallaby Grasses and Kangaroo Grass. In common with almost all the other farmers using this type of grazing land, our land has suffered from our lack of knowledge about the plants we are managing. Our past grazing practices—large paddocks set stocked throughout most of the year—have led to a decrease in quality and biodiversity of these pastures, and to a corresponding downward trend in productivity.

With new information on native grasses and their management, we are in the process of changing our grazing regimes to encourage the regeneration of the native grasses, to improve their utilisation, and to increase the biodiversity of our grassy woodlands so that we have a more sustainable grazing system.

*Keywords: production, overgrazing, education.*

The explorer Edward John Eyre travelled through the Clare district on his way north in July 1840 and reported very favourably, describing it as a 'valuable grazing district, with grass of an excellent description, and of great luxuriance' (Eyre 1845). Eighteen months later my great-grandfather and his brothers settled here, building their head station some 10 kilometres north of what is now the township of Clare.

My great-grandfather started out with 2,500 sheep, and 20 years later his flocks had grown to 87,000 sheep running over a large area of leased country to the north and west of Clare—the typical South Australian squatter. Until the 1870s, those sheep were shepherded across the leases as natural water points allowed and penned into portable sheep folds at night for protection from dingoes—that is, they were rotationally grazed across the available land.

My great-grandfather grew rich on wool, and his descendants remained predominantly sheep farmers until the mid 1990s when poor wool prices forced them, along with most farmers in this area, to intensively crop their arable land.

Family members own several paintings depicting the countryside as it was on my great-grandfather's property within a few years of settlement and these landscapes are easily recognised today. The eucalypts remain on the higher ground, but the she-oak has disappeared and the open plain of the valley floor, which would have been native grasses, was ploughed up and replaced by pastures and crops many years ago. This is typical of what has happened throughout the Mid-North of South Australia.

Remnant grasslands and grassy woodlands remain on the 8 small parallel ranges of hills extending north–south through the Mid-North, while the valleys are cropping land. Early survey maps show that the higher rainfall areas, such as the area around Clare where the predominantly winter rainfall is about 500 mm, are typically eucalypts on the higher ground, she-oaks on the lower ridges, and open grassland in the valleys. On the drier ranges such as those around Burra and Mt Bryan, where the rainfall drops to 400 mm or less, there were few if any eucalypts, the she-oaks and acacias were in scattered groves and the grasslands were more dominant.

Our farm, due north of Clare, is approximately 60% non-arable open woodland, and this is predominantly SA Blue Gum (*Eucalyptus leucoxylon*) and Peppermint Gum (*E. odorata*) with a grassy understorey that is grazed by sheep and cattle. The remaining 40% of the farm is arable and at present is continually cropped with a rotation of cereals, legumes and Canola. There are creeks and rocky ridges running through the arable ground, which have grassland and grassy woodland on them, and it is on these small patches that we have the greatest diversity of native plants. Altogether I have found 113 species of native plants, all occurring on these islands in the arable ground—the grazed land only has about 13 species and 4 of these are trees. We have also seen 100 species of birds and we have small populations of both Euro and Western Grey Kangaroos, the odd echidna, brushtailed possums, six species of bats, and many feral species (including a large herd of fallow deer) that we could well do without.

We graze our animals on the crop stubbles in summer and put them into the hill paddocks after the autumn break, leaving them there until harvest. So, effectively, our native pastures are set stocked from April until December, a practice in line with most other mixed farms in the Mid-North. Since wool prices collapsed, most farmers here have turned to high input, continuous cropping on every hectare they can in order to survive. Ten years ago, at the end of the wool boom, 70% of our gross farm income came from our sheep enterprise, today it is about 20% and cropping now provides the major part of our income. This increase in cropping income is the result of continuous cropping using a high input system. But while our turnover has increased dramatically, our profits have not and we have come to the conclusion that this system is not sustainable in the long term.

I used to think our grassy woodlands were in pretty good order and felt pretty smug about the biodiversity of our farm, but that was in the days before I became a Native Grassland Extension Officer with the World Wide Fund for Nature (WWF)—and I learnt to look at the ground! I now realise that my grassy woodland is in trouble. The pressure of the last 8 years of set winter stocking in the woodlands is showing and we are now seeing a drop in production from this area, with a correspondingly rapid increase in annual weeds. There has been a dramatic drop in the size and number of native grass tussocks and the forbs have almost completely disappeared, except for a few hardy, obviously unpalatable ones like Variable (Corrugated) Sida (*Sida corrugata*), Grassland Wood-sorrel (*Oxalis perennans*) and Pink Bindweed (*Convolvulus erubsecans*).

And we are certainly not alone. Every grassland or grassy woodland I have seen in the Mid-North—with a few notable exceptions—is in the same trouble. I believe there are three main reasons for this:

1. We do not value our grasses. Farmers of the past two generations have almost been brainwashed into believing the grasses are almost valueless as pasture plants. SA Primary Industries and the small seeds industry have done a fantastic job promoting legumes—medics, clovers and, to a lesser extent, Lucerne. It hasn't helped that the two major crop weeds here—Wild Oats (*Avena barbata*) and Ryegrass (*Lolium spp*)—are grasses, or that Ryegrass hosts a nematode that causes annual Ryegrass toxicity, which is fatal to livestock grazing on infected Ryegrass. The message has been that grasses are troublesome weeds and have to be eradicated, and legumes are God's gift to grazing animals.
2. We have forgotten how to manage perennial plants. Our farming systems are geared to annual production. Our crops are annuals, our legume pastures are annuals, and we think annually—that is, in production years rather than long term. Except for small areas of Lucerne, I doubt that there has been a perennial pasture sown in the Mid-North for the past 30 years and most of what existed before that has long gone. Native grass pastures are predominantly perennials and need different management. We have been unconsciously selecting for annuals and that is why our grasslands are being overrun by weeds such as *Erodium spp.*, Wild Oats and Salvation Jane (Patterson's Curse) (*Echium plantagineum*).
3. Most importantly, farmers don't know their native plants. They usually know their weeds, but very few can recognise Kangaroo Grass (*Themeda triandra*) or Wallaby Grass. If farmers don't know what plants they have, how can they hope to manage them so that they can increase their productivity?

So what can we do to help our native grasslands and grassy woodlands? Are there any solutions to the overgrazing problem? I believe there are, and some of those things are already happening:

- Educating the farmer is absolutely essential. With my fellow Extension Officer with the WWF, botanist Ann Prescott, we have visited over 80 farmers, identifying and giving them information on the plants on their properties and generally raising their awareness about native grasslands. While there are plenty of farmers still to be contacted there is no excuse for anyone not to access information. We also have Grassland Information Sheets that we give to farmers and other interested people to raise their awareness of the issues of grasslands.
- Changing farmers' grazing practices is, I believe, critical to the survival of grasslands. We need to select for perennial plants and it appears from research both interstate and overseas that the best way to do this is to use some form of rotational grazing. We need to have grazing trials running in the Mid-North so that we can have local data to show farmers which grazing systems work best in this area. The other grazing option is to use a very low stocking rate. We have seen some remarkably good grassland that has been continuously grazed at about 2.5 sheep/ha. This seems to be the rate that, in this district, allows the grassland to survive in very good to excellent condition. However, unless the 2.5 sheep/ha are growing heavy fleeces of less than 19 micron wool (which is unlikely in SA) this is hardly economic at today's wool prices. However, some people will go for this low input–low output option as it has proven to be a sustainable grazing system over the long term.
- Encouraging farmers to set aside areas with good or potentially good grassland will ensure that biodiversity of the region is increased and a seed source maintained on the farm. We have seen some excellent small areas, e.g. ridges, waterways and creeklines, that have been protected from grazing, either by fences or by being in the middle of a paddock that has been continuously cropped for years. These areas can have 60 or more species on them and it seems that, if such areas have never been ploughed, they can recover from years of grazing to become quite healthy and diverse grassland areas.

So there is hope for the future of grasslands in the Mid-North of SA.

For my family, we have looked at what we can do and made some decisions that we hope will lead to a win–win for both our business and our grassy woodlands:

- We are going to reduce our cropping to the minimum necessary for our survival, mainly because we believe that the high-input farming we have been practicing is not sustainable. We have embarked upon a fencing program to completely re-fence our grassy woodlands so that we can rotationally graze them. Instead of having 6 paddocks with an average size of 160 hectares, we will have 48 paddocks with an average size of about 20 hectares. We are already running fewer mobs of sheep so that we can rotate them through the paddocks we have now, and by increasing the recovery time between grazing we hope to increase the size and number of the grass tussocks.
- We have started to monitor our plants as well as our livestock. In the past we managed only the livestock and only noticed that there was a lot of feed or that the feed was running out. This is a very important change. By observing the plants and removing the animals before the plants are overgrazed we will give our native pastures more opportunity to be both healthy and productive.
- We can recognise our plants and manage them to give them the best opportunities. We know that we want to encourage the native grasses and we need to give them an opportunity to set seed and to establish seedlings. Now that we know their life habits, we can do this.
- Thanks to a Natural Heritage Trust grant, we are fencing off the creeks and ridges that are high in biodiversity to protect them and allow further regeneration, and hopefully provide a seed source for our grassy woodland pastures.
- Better management of our pastures should translate into cleaner, stronger, more consistent fleeces from our sheep, which should translate into better prices for our product.
- We have made the decision to stay in the wool industry and be one of the 20% highly profitable producers in that industry. Better management of our native pastures is critical to that decision.
- And we are planning that our great-grandchildren will have the option to be farmers if they choose to be, as we have had that choice. We aim to bequeath to them a healthy farm with a sustainable production system.

It is exciting to be making these decisions at a time when the value of our native grasslands is at last being recognised. There is much to be learnt, particularly in South Australia where we are lagging behind the eastern States in our recognition and management of this important resource. As both a Native Grasslands Extension Officer and a farmer managing grassy woodland, I have a wonderful opportunity to be part of this re-evaluation and I strongly believe that, as our knowledge increases, there are going to be some very positive outcomes for both land managers and conservation.

## References

Eyre, E. J. 1845. *Journal of Expeditions of Discovery into Central Australia and overland from Adelaide to King George Sound in the Years 1840-1 - Volume 1*. T and W Boone, London. Facsimile Edition published by the Library Board of South Australia, Adelaide, 1964.

# Native grasslands in Tasmania

Cynthia & Tom Dunbabin

'Bangor', Dunalley TAS 7177
Bangor@tassie.net.au

The grazing enterprises at Bangor are critically dependent on native grass species, predominantly Kangaroo Grass (*Themeda triandra*), which occur as components of grassy understories in woodlands. Careful grazing management, with summer spelling and autumn patch burning every 5-10 years, maintains the diversity and productivity of this valuable resource.

Bangor, as with many Tasmanian grazing properties, retains its native grasslands because of a combination of historical circumstances: managers who were graziers rather than farmers, relative financial stability and continuous intergenerational ownership by people who had a love of and regard for native vegetation.

Currently, the 'two edged sward' is finely balanced between the desire of owners to preserve native grasslands and the imperative to maintain financial security. The greatest single threat to native grasslands in Tasmania is the dire economic state of the wool industry. Woolgrowers are turning to cropping, cultivating arable native grasslands and increasing grazing pressures. No matter how great the desire to conserve, the need for financial viability is imperative to survival.

The solutions are varied, from an improvement in fortune for the wool industry and alternative land uses based on tourism/recreation to management agreements and covenants aimed at protecting native grasslands.

A desire by landowners to maintain native grasslands, together with management skills and financial viability, are essential if this important part of our natural heritage is to be protected.

*Keywords: Tasmania, grazing, native grasses*

## Introduction

This paper discusses native grassland management in Tasmania generally, using examples and issues we face on our grazing business at 'Bangor' in Tasmania's south-east (Fig. 1). Bangor is a 6,200 ha property, of which 800 ha have been cleared and sown with introduced grasses and legumes, and the balance is native vegetation. The management aims are to maintain a viable agricultural, grazing and forestry business and protect and enhance the natural and cultural diversity values. Importantly, Bangor is where we live, our home, and land management practices must take account of this.

## Native grasslands

At Bangor, our native grasslands are an understorey to a tree layer of varying density, from scattered Eucalypts and Acacias to quite dense forests with closed canopies. As would be expected from such a range of vegetation types, the diversity of species is large. The major grass species is *Themeda triandra*, with *Danthonia*, *Poa*, *Elymus*, *Deyeuxia*, *Stipa* and *Microlaena* species also present. There are also a wide range of perennial and annual herbs. Most grasslands also have a range of shrubs, dominated by Acacias but including *Bursaria*, *Allocasuarina* and *Dodonaea* species among others, either as the major 'tree' layer or as a true shrub layer beneath a eucalypt tree overstorey. The major eucalypts are *Eucalyptus pulchella*, *E. ovata*, *E. viminalis* and *E. globulus*.

The native grasslands and woodlands are a vital component of the grazing capacity at Bangor. Although they account for less than 20% of the total grazing capacity of the property, they support up to 40% of it during winter (Fig. 2). From a grazing business management perspective, the native grasslands allow us to over-winter livestock that we would not otherwise be able to carry. As far as the grasslands are concerned, the fact that they are grazed heavily in winter and spelled


Figure 1. Bangor is situated in Tasmania's South East

during summer suits the growth habit of the grass species, particularly Kangaroo Grass (*Themeda triandra*), very well. Introduced pasture grasses are able to persist and reproduce under heavy grazing pressure, as they have been bred and selected for this very characteristic. Kangaroo Grass, on the other hand, does not survive if heavily grazed in its active growth phase, during summer. As can be seen from Fig. 2, grazing is minimal during these months, but increases considerably during winter.

## Tasmania in general

Native grasslands and woodlands were once widespread throughout Tasmania's midlands and east coastal areas. Large areas of what were once native grasslands have been 'improved' by cultivation, oversowing with grasses and legumes, and applying fertiliser. This, combined with inappropriate grazing management of the non-arable areas, has led to the removal of native grass species. This is particularly so on the better soil types, even where slopes are steep and surfaces rocky. In many areas, only small remnants survive as examples of what were extensive areas of native grassland.

Organisations such as Greening Australia have produced a variety of material about native grassland management, but most relates to revegetation rather than management of existing grass swards. 'City Parks and Cemeteries' published by the Tasmanian Conservation Trust in 1988 is an excellent reference for species and communities of Tasmanian grasslands. It highlights a number of areas in desperate need of conservation, but ten years later progress has been slow.

Tasmania's fine-wool growing industry depends on native grasslands and woodlands. They provide a balance of good nutrition and country that is free of annual grasses that seed and contaminate wool. This type of wool has traditionally attracted the price premiums that have encouraged owners to maintain their grasslands as a major resource for grazing. The downturn in the economic well-being of wool growing, and the major adjustment this will cause, pose a significant threat to native grasslands. The incentive to manage them for grazing and wool production is no longer there. This has been replaced by increasing pressure to cultivate remaining arable areas for cropping and, in some cases where annual rainfall is reasonable (>600 mm), to plant trees for farm forestry.

A significant factor in the maintenance of native grasslands in Tasmania has been the stability of land ownership. The retention of large holdings, and the building of grazing management experience and expertise over generations has facilitated the retention of extensive grasslands. In many areas of Australia, the subdivision and selling of properties has frequently led to wholesale changes to management, which in turn has led to the degradation of native grasslands.

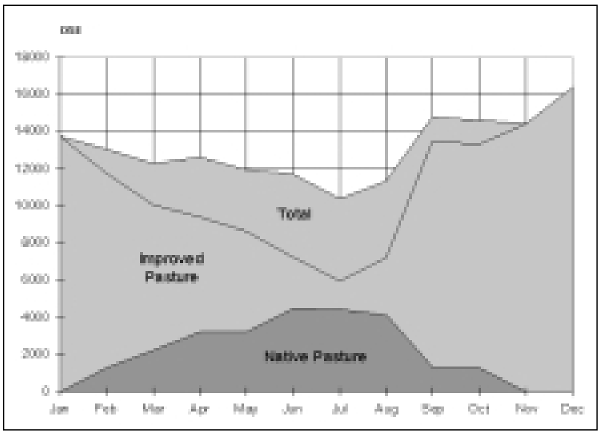



Figure 2. Average annual livestock carrying capacity of Bangor

## Management for persistence

Our experience at Bangor, gained from four generations of Dunbabins, has shown that extensive areas of grassland can be managed both as a grazing resource and an important conservation resource. Fire is an important management tool and regular burning is critical, not only in maintaining grass dominance to maximise the value of the grazing resource, but also in maintaining botanical diversity. This management closely reflects that practised by Aborigines for thousands of years. In their case they were managing to promote grasses most favourable to the marsupials they hunted, and in our case we manage for sheep and cattle.

Burning every 7-10 years during autumn in a patchwork manner ensures grass dominance by preventing ingress by *Lomandra longifolia*, Bracken Fern, *Bursaria spinosa*, *Acacia* species and a host of other native shrubs. In a trial conducted at Bangor to gauge the effect of fire in maintaining grass dominance, an area of a few hectares has been left unburned for the last two firing cycles on adjoining areas. This has resulted in a substantial increase in shrubs and small trees at the expense of ground cover plants. During recent burning of a nearby area, fire escaped to part of the unburned trial. Despite the almost wind-free conditions at the time, the extra fuel load of leaves and bark resulted in a hot fire that was difficult to control, and that caused considerable damage to smaller trees, compared to the adjacent area.

In addition to regular rotational grazing on an annual basis, it is critical to manage for seasonal variation. Native grasslands have been considered by many managers as sacrificial areas to be grazed heavily during periods of below average rainfall. This practice has been the cause of much of the degradation throughout Tasmania, particularly in the dryer areas. At Bangor we certainly utilise native grasslands more heavily during dry periods, but, most critically, also defer grazing to allow recovery during the wetter seasons that inevitably follow. This is relatively easy from a management sense as there is ample feed in other areas during good seasons. Management practices during periods of environmental instability, such as very dry seasons and immediately following burning, are the most critical. Damage to native grasslands, either in terms of reducing plant density and vigor or introduction of weeds occurs at these times.

Weeds pose a significant threat to many native grassland areas. Introduced pasture grasses and legumes as well as weeds such as thistles are quick to establish in disturbed areas, particularly stock camps where nutrients are at elevated levels. At Bangor, we fence and rotationally graze to minimise stock camps, and are forever vigilant about weed removal. A recent introduction of Serrated Tussock (*Nassella trichotoma*) has caused major problems, particularly as without seed heads it is very difficult to distinguish from the native *Poa rodwayi*. The seeds are carried on the wool of sheep and although numbers of plants are low they are spread over an extensive area.

## What the future holds for Bangor's native grasslands

As valuable as native grasslands are in terms of offering grazing capacity in winter, there remains a large difference in the overall grazing capacity between native grasslands and improved pastures. At Bangor, our improved pastures carry between 12 and 15 DSE/ha compared with 5 to 7 DSE/ha for the better areas of native pasture, down to below 1 DSE/ha for woodland areas. The economic benefits of being able to carry between 2 and 10 times more livestock as a result of pasture improvement do not need too much explanation. For the better areas (5 - 7 DSE/ha), the benefits of input free (or at least minimal input) native pastures outweigh the lower stocking capacity. However, for areas that carry less livestock, large economic gains can often be made through clearing and pasture improvement.

To date, we have been able to expand our business without greatly impacting on native grasslands due to the advantages of growing superfine wool and grazing cattle in winter in these areas. However, if the current downturn in wool leads to a major readjustment in grazing priorities this may well not continue and we may have to look at ways of improving the productivity of native pasture areas. In some areas we have thinned the tree overstorey using stem injectible herbicide. This has been partially successful, but regrowth continues to occur and the process is time consuming and expensive. We have also conducted trials using introduced clovers and some fertiliser to improve Kangaroo Grass productivity. This has been quite successful to date, with the added phosphorus and nitrogen boosting productivity, and the careful grazing management ensuring plant persistence and reproduction. In the initial years, plant density of Kangaroo Grass was reduced as clover became established, but with time it has responded to the improved fertility and plant density has been restored.

Ongoing subdivision to enable shorter grazing rotations (or, more correctly, longer spelling periods) has greatly improved productivity of improved pasture areas at Bangor. There is no reason why these gains cannot be made with native pastures, but the increased returns are relatively less and the cost of fencing higher than for improved pastures.

Bangor is managed for a multitude of uses, including conservation and recreation. Conserving grasslands for their biodiversity values is important to us, but it does not pay the bills. Increasingly, the community is becoming interested in conservation issues and there is a growing interest in plant communities that are rare and diminishing. We currently conduct tours for visitors at Bangor, which feature our natural and cultural heritage, and this activity may well increase in time to become a valuable enterprise.

Looking further ahead, it will be economically increasingly difficult to manage extensive areas of native grasslands unless the current trend of declining terms of trade for the grazing industry is arrested. There will be pressures to change land use, further intensification and alternative enterprises that may well be detrimental to native grasslands. If the 'community' expects their retention, then the 'community' may well have to contribute to their retention with some financial support.

## The needs of Tasmania's native grasslands

As indicated previously, there are many areas of Tasmania where native grasses once dominated the landscape that are now dominated by improved pasture and crops, with the grasslands reduced to remnants. These areas need urgent attention to prevent further decline and to institute management regimes that will enhance their conservation values. In some cases, grazing properties still have large areas of native grasslands and all possible measures need to be taken to ensure they remain as single properties and are not subdivided. If there is a change in ownership and/or management then the practices that led to the retention of the grasslands needs to be passed on. For such properties, there should be a mechanism that enables the high conservation value areas to be retained without adverse financial implications for the owner.

There exists a wealth of knowledge among managers and shepherds who work on properties with retained native grasslands, which needs to be recorded and made available to others involved in grassland management. Much of this information is specific to the particular property, but there are many principles that could be drawn out that are not generally understood or practiced.

Many landowners have some knowledge of the management practices needed to maintain grasslands, but they have neither the finances nor the motivation to implement them. Managing extensive grazing areas is very challenging in the current economic climate and, as mentioned, is unlikely to change. Information about native pastures must be provided along with the general support mechanisms and learning opportunities for land managers. There is a large amount and variety of information available that relates to native grasses, but little of it is of practical help to graziers. The various aids to identification are very good and an important first step. However, there are many more steps that need to be made before better management practices are implemented.

# Monaro, NSW – A question of need

Charles Litchfield

PO Box 5, Cooma NSW 2630
coroo@snowy.net.au

‘*As businessmen, pastoralists can be expected first to seek to survive, second to make profits and third to maintain productivity for long term survival. That is, the needs of the future only become important after current needs have been satisfied.*’ (Young *et al.* 1985)

The Monaro is an ill-defined area extending roughly from Canberra in the north to the Victorian border in the south and bounded by the Snowy Mountains to the west and the coastal Kybean range to the east. Alec Costin's (1954) study estimated the pre-European extent of the grasslands to be about 250,000 hectares, ranging from an altitude of 600 to 1400 metres. Annual rainfall is low (between 450-700 mm), particularly in the tableland tract, which is subject to a rainshadow effect. And yes, it is bloody cold.

Ninety-five per cent of the gross value of agricultural production on the Monaro comes from sheep and cattle. Since 1967 there have only been 8 years without a drought declaration. Grassy weeds cover up to 20% of the grasslands, reducing the amount of wool cut by 1.5 million kilos.

Maybe 2% of the grasslands on the Monaro have good enough structure and diversity and are free enough of exotic species to be called high conservation value grasslands. A large proportion exists in a semi natural state—substantially modified and dominated by a small number of native perennials. It is these grasslands where I believe something close to a balance between the needs of people and the exploitation of the ecosystem where they live has consciously taken place for nearly two hundred years. Today, for most farmers on the Monaro, life is not so much a case of balancing production and conservation—but of survival.

The Monaro is therefore a place where all the contemporary questions about grasslands are in sharp focus, and maybe one day we will have some answers. But the most important questions have still not been asked, let alone answered. For example—What do we want our grasslands to look like? Is that picture compatible with the needs of the people who live there? Can everyone really share that vision? And if so, how much can we realistically influence the massive market and natural processes to create it?

This paper will use the Monaro to illustrate how our institutions have failed to respect not only the fluid nature of the grassland ecosystems, but also the multiple goals of the people who manage and live in them. And conclude that it is not so much a matter of being able to balance production and conservation, but address the reality of the current needs of people who depend on grasslands for a living, while being pragmatic about the needs of a vastly altered ecosystem.

## Save the grasslands or save the people?

I would like to use a verse from David Campbell's poem ‘The Monaro’ that not only gives a feel for the stark landscape, but for the attachment of its people to that landscape.

*Willy Gray has a lover's eye*
*And it goes over the twin bare hills*
*And the blond paddocks to the bleached sky*
*Until it has come to a thought that fills*
*His mind with tenderness for this wild*
*Upland country and her suckling child*

Willy Gray's love for the breast-shaped hills of the Monaro borders on a deeper dependence on the landscape. This intimate connection between landscape and people is recognised not only by poets, but also academics and politicians. However, it still doesn't translate easily into policy.

Sir Keith Hancock (1972), Steven Dovers (1986) and, more recently, George Seddon (1994) have described the historical and geographic scene on the Monaro. The relationships between the ecosystems, the human systems and the landscapes they shape are central to the dialogue. These relationships are described as endless, unpredictable, complex, dynamic, heterogenous in time and space, with multiple causes and multiple effects.

I believe that our failure to understand the 'endless and unpredictable' relationships, and then integrate policy in light of them, has left us unable to adequately address the needs of either the grasslands or the people who use them.

While it is not hard to find a 'recognition' of the connection between grasslands and the people who manage them, we have yet to see a real attempt to integrate their multiple needs into policy. The NSW native vegetation legislation is a case in point. Put very simply, after rushing through legislation to prevent clearing of grasslands, social fairness and equity were never factored into the final product. The outcome has been policy and law that is not meeting the needs of the grasslands or people who manage them.

Efforts to get around legislation, the expense of selling unpopular policy and catching the law breakers has ended up becoming more important than the initial goal, which was to protect high conservation grasslands.

Although this may all sound obvious, we don't seem to have come far in 130 years. In a submission to a Select Committee on the Administration of Land Laws in the 1860s, my great-great-grandfather expressed 'a dislike of the subterfuges which he and his kind had been practicing'. He goes on to say that 'they would remain a necessary evil, until such time as the law was made conformable with the environmental and economic facts of life on the land.'

This is really only another way of saying that we need to better integrate economic, social and environmental policy. Until we do, we will not be able to properly address the needs of anyone.

## Background to the Monaro

It has been said that regions exist in the minds of men. Nowhere is this more true than the Monaro.

The Monaro is an ill-defined area extending roughly from Canberra in the north to the Victorian border in the south (Fig.1). The Snowy Mountains form the western boundary and the coastal Kybean range forms the eastern limits.

Alec Costin's (1954) study of the ecosystems of the Monaro estimated the pre-European extent of the grasslands to be about 250,000 hectares, ranging from an altitude of 600-1500 metres. Benson (1994) described 8 grassland communities in his survey of the Monaro in 1994. Of the 190 native taxa recorded, only five were registered as rare or endangered. Most of his grassland sites contained more than 35% exotic species.

The distribution of these grasslands is determined more by periodic drought and low rainfall (available soil moisture) than other factors such as soil type. Costin (1954) attributes the treeless nature of grasslands on the basalt to low rainfall, high wilting point properties of the heavy textured soils, desiccating winds, frost, rapid percolation, and poor aeration.

Rainfall can be as low as 450 mm in the rainshadow areas such as Dalgety, and runs up to over 900 mm in the grasslands up on Snowy Plain. Polish explorer Strzelecki, in a despatch to Governor Gipps in 1840, refers to the extraordinary droughts of the alps area (Hancock 1972). Since 1967, there have only been 8 years without a drought declaration (Cooma RLPB 1998), leading to serious questions as to what is a 'drought' and what are normal conditions on the Monaro. Most of the Monaro has about 3 months without frost. Nimmitabel has a mean frost-free season of only 2 months.

Ninety-five per cent of the gross value of agricultural production on the Monaro comes from two commodities—wool and beef. Sheep numbers in the Cooma RLPB have averaged about 1,100,000 for the last 20 years and outnumber cattle by about 20:1 (Dovers 1986). Softwood forestry is moving gradually into the higher rainfall areas in the south—providing some structural adjustment solutions, but also some land use questions.

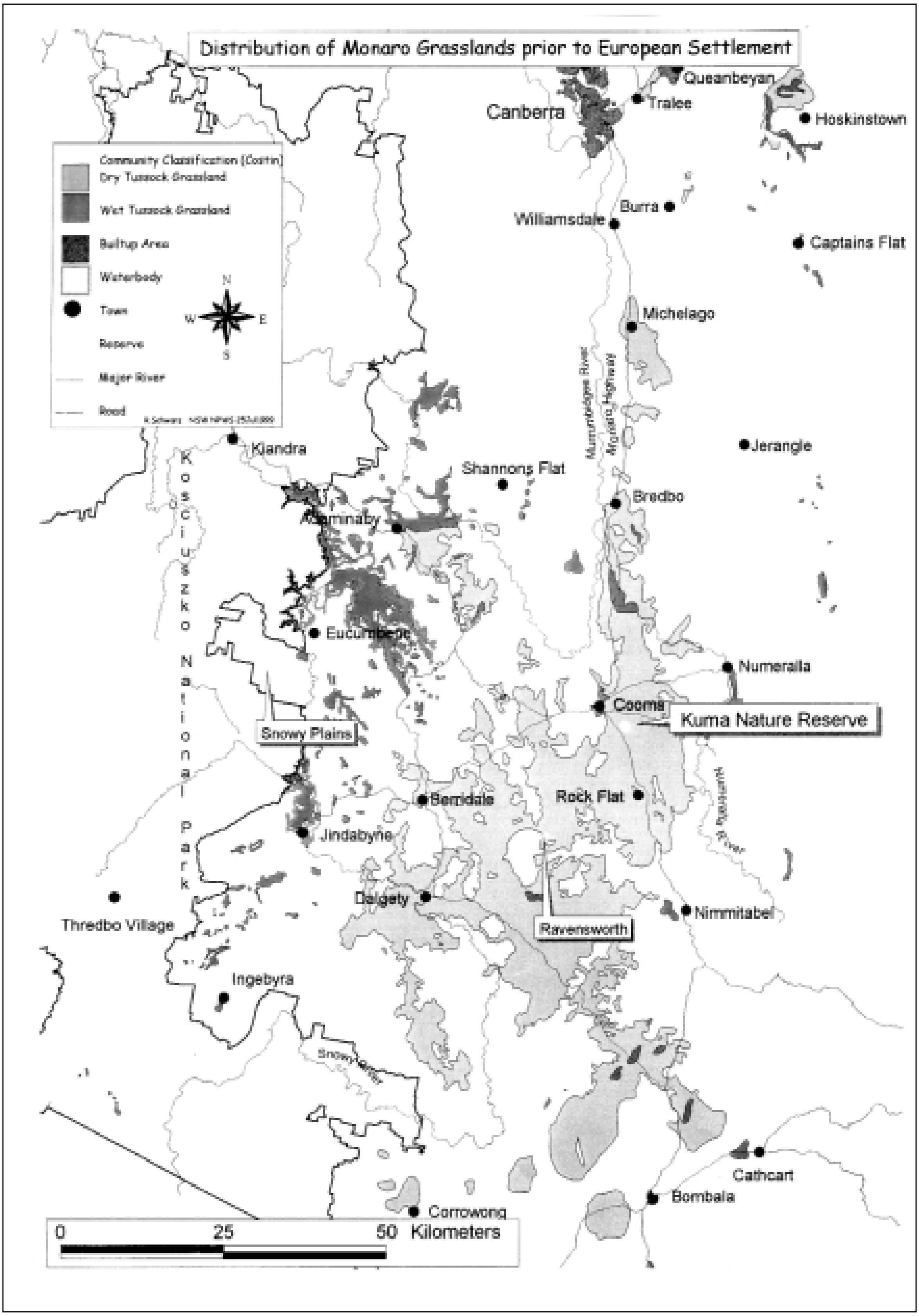
These are all reasons why Steven Dovers (1986) said—'the Monaro landscapes are not conquered ones, with humans in managed control, but places where the land user rides the limits of the setting'.

These are also the reasons why the Monaro has a character and quality that cannot be found anywhere else in the world and, in the end, makes it such a beautiful place to live.

## Landholder perspectives of conservation and production

Managing grasslands for their *conservation* value is an ecology-centred process that relates to the limitations of seed dispersal, recruitment characteristics and nutrient availability. I am having a go at this with an enthusiastic team of people who are trying to manage New South Wales' first

Figure 1.


Distribution of *Monaro Grasslands* prior to European Settlement
Community Classification (Costin)
Dry Tussock Grassland
Wet Tussock Grassland
Builtup Area
Waterbody
Town
Reserve
Major River
Road
N
S
E
W
Queanbeyan
Canberra
Tralee
Hoskinstown
Burra
Williamsdale
Captains Flat
Michelago
Murrumbidgee River
Monaro Highway
Jerangle
Kiandra
Shannons Flat
Bredbo
Adaminaby
Kosciuszko National Park
Eucumbene
Numeralla
Cooma
Kuma Nature Reserve
Snowy Plains
Berridale
Rock Flat
Jindabyne
Numeralla River
Dalgety
Nimmitabel
Thredbo Village
Ravensworth
Ingebyra
Snowy
Cathcart
Bombala
Corrowong
0
25
50
Kilometers

grassland reserve, near Cooma, and I can tell you that it is not an easy task. Trying to merge my personal goals for the reserve with those of the local threatened species team has been an interesting exercise.

Managing grasslands for their production value is a human centred decision-making process that relates directly to the needs, values and goals of the manager. My family has managed grasslands for their production value for 140 years. I believe that on our farm we may have spent periods of time achieving some sort of balance between conservation and production. This is possible when using a resilient resource like our *Poa* grasslands, but may not be possible in all grassland communities.

With periodic droughts and declines in the terms of trade, we have often been pushed to the point where concern for issues like recruitment of the native species becomes less important than getting the sheep through winter. In my view, I was often just unable to balance conservation and production as well as satisfy the needs of my family, on what is considered one of the better blocks on the Monaro.

There will be as many views of what it means to balance production with conservation as there are landholders. It will depend on the equity of the landholder; it will depend on whether the farm is the only source of income; it will depend on the perceived value of the vegetation that is on the property; and, it will depend on how much you need to push that farm to survive.

Ikerds (1997) suggests that the fundamental purpose of agriculture is to shift the ecological balance so as to favour humans relative to other species. That is, to *ensure* that there is not a balance between the ecosystem and the people who use it.

We must be realistic about the capacity of professional farmers to pursue 'conservation' as a goal, even if they think it is desirable. Short-term survival comes first and profit comes second. Farmers will spend time either using or resting their resource and, occasionally, they will spend time with this in some sort of balance. *Maintaining* equilibrium (even if you could identify where it is) may not be a realistic goal over a long period of time in an agricultural system where the landholder's needs and climatic, ecological and economic processes are so unpredictable.

That should not stop people in more flexible situations from setting themselves the goal of trying to balance conservation and production. Some landholders I know are quite happy to work towards an ill-defined point of balance between 'conservation' and 'production', even at some cost.

So what might balancing conservation and production look like? The only people I can think of at home who make decisions in the light of recruitment characteristics, energy and nutrient availability are those who have been through a Grazing for Profit school. Using the Holistic Resource Management (HRM) tools brings them close to what I think balancing conservation and production looks like. The HRM tool requires a quality of life, production and landscape goal. It is a management tool that uses the resilience and persistence of the pasture base and harvesting energy over appropriate scales of time to make a profit. There are some good lessons to be learnt from the model.

I believe the goal of 'balancing conservation with production' may be a bit like having sustainability as a goal. You will rarely know if you are achieving it and you will have trouble measuring it, but that should not stop us trying to do it.

And like sustainability, this responsibility does not start and end on the farm. George Seddon (1994) writes—'*We all exploit the land to sustain ourselves, whether we be miners or academics. The questions are not whether, but how and how much.*'

Everyone should accept some responsibility for trying to achieve this balance.

## Conservation of what?

It is quite clear that, since the initial major impacts of settlement on native species, agriculture on the Monaro has gradually changed the nature of the grassy landscapes.

Perhaps 2% of the grasslands on the Monaro have good enough structure and diversity and are free enough of exotic species to be called 'high conservation value grasslands'. Our goal should be to protect these grasslands.

Grassy weeds cover up to 20% of the grasslands (Jones & Campbell 1998) and threaten a substantial area of annual-dominant improved pastures and semi-natural grasslands. Our goal here should be to address the causes of weed invasion rather than the symptoms, and allow them time to heal themselves.

The majority of grasslands on the Monaro exist in a semi-natural state—substantially modified and dominated by a small number of native perennials (Benson 1994). While it is relatively simple to set some goals for the high conservation and more degraded grassland, there is an urgent need to identify what our goals are for these semi-natural grasslands. Do we want to maintain or enhance the composition of these grasslands? Do we want the people who live in those grasslands to just survive or to prosper? What do we want this landscape to look like?

To add to the complexity, the high conservation and semi-natural grasslands are in a constant state of change (with occasional periods of stability) that is driven by a combination of management and unplanned natural events.

I am not sure that we can afford to have an each-way bet on what should happen to the areas of heavily modified grasslands that form the production base of the Monaro, for two reasons. Firstly, there is questionable cost/benefit in trying to protect what are drastically altered systems; and secondly, it cannot be achieved equitably at present given farmers' dependence on these systems for income.

If it *is* important to protect the status of the substantially changed grasslands, then we must provide reasons that make sense to the managers and meaningful rewards for their contribution.

## Incentives and mechanisms for conservation

Young *et al.* (1985) have written that 'as businessmen, pastoralists can be expected first to seek to survive, second to make profits and third to maintain productivity for long term survival. That is, the needs of the future only become important after current needs have been satisfied.'

Developing meaningful incentives is crucial to the long-term conservation of our grasslands, but we should be aware that farmers seek survival first and profits second.

During yet another 'drought' in the 1980s, we spent substantial amounts of money keeping our cattle alive. We were quite prepared to lose money to hold on to the genetics of our livestock. I am aware of people today who are living well below the poverty line, losing wealth until they can return to the job of feeding and clothing the world. Quality of life, pride as woolgrowers or cattlemen, and social status are all part of a powerful cocktail that, along with financial survival, drives motivation and management in grasslands.

Individuals and even institutions may not have the capacity to invest any money at all, so incentives may not be enough. In the south of the Monaro, some incentive schemes are not being taken up because people are unable to go dollar for dollar in cost-sharing arrangements.

Despite the best intentions, some incentives are full of disincentives. The Cooma office received in excess of 50 expressions of interest in response to the Native Vegetation Act incentive scheme that forms the social 'fairness and equity' component of our State vegetation reforms (15 million dollars for the entire State). Not one local application has been funded yet and I expect only a handful will get to the line. The applications are too complex to complete and it is too difficult to qualify.

There have been a few wins—Landcare groups and individuals working with the World Wide Fund for Nature (WWF) and Greening Australia are protecting small areas of native vegetation on private property, but no one is pretending that stitching off a corner of the farm is achieving a balance of conservation with production. What these programs have done is allow people on the Monaro to build some trust, learn about the value of native vegetation and to take the first small steps. I applaud the intent of these initiatives in NSW, but I would argue that in many cases conservation is still costing people money.

It is hard to see full value being paid for food or fibre *plus ecosystem services* then properly reinvested back into the system in the near future. It is still not uncommon to go to a conference where someone stands up and says that we must get people to pay more for food at the supermarket and that they are willing to pay. The reality is that Coles, Woolworths and Franklins are at war with each other and must discount to guarantee their own survival.

In the mean time, long-term funding for a well-managed, regional network of the higher conservation value grasslands and other vegetation communities of the Monaro would achieve results quickly. Existing areas of vegetation on Crown land, travelling stock reserves, or State Forests should be the first to be included. Some of these are large areas of high value that are still being poorly managed and resourced. The network would grow slowly over time, with willing landholders committing areas to the network in return for incentives linked to the discount to production. As the network grows, acquisition and lease-back may be an option. The outcome would be a large, representative network of the region's grasslands and other native vegetation.

No matter how hard we spell out the benefits of looking after grasslands on individual properties, management will not change until the rewards of doing so are greater than the costs. We need to find and offer meaningful rewards now and stop handing the costs of retaining native vegetation on to farmers, until we come up with a better idea.

## Conclusion

Up until now, it has seemed that the policy approach has focused our science and law on the need to 'save' our grasslands. I am now confident that there is an understanding that once we have protected our highest value areas, we must use our grasslands for the greatest benefit.

This conference for me is about acknowledging that we are not trying to reconstruct our grassland ecosystems, but using them in a way that might not only retain some of their values, but also benefit the manager along the way.

So I will conclude by saying that we need to look for simple actions and get on with it where we can. We cannot afford to keep arguing about management structures and regional plans when there are potentially good outcomes just sitting there ready to happen. Taking small steps towards whole networks of vegetation, including grasslands, is a good example. We need to start with the areas of public land and with landholders who have already shown enthusiasm, rather than struggle to get everyone on board. Over time we will end up with a large enough area of sufficient quality to make a difference.

We need to develop clear goals that take away some of the confusion in what is already a complex management task. We should acknowledge the reality of the extent of modification of our grasslands, look at the costs and benefits, and adjust our goals accordingly.

The greatest value of grasslands is their incredible resilience and their low maintenance. We need to sell this value and recognise that providing financial incentives will only be part of the deal when it comes to motivating managers of grasslands.

And lastly, the grasslands are infinitely unpredictable and the needs of the managers can change as quickly as the system they live in. We desperately need good adaptive policy that integrates the economics and ecology of our grasslands, so that the goals of the people are somewhere in line with what we believe are the needs of the grasslands.

## References

Benson, J.S. 1994. The native grasslands of the Monaro region: Southern Tablelands of NSW. *Cunninghamiana* 3(3): 609-50.

Costin, A.B. 1954. *A study of the ecosystems of the Monaro region of new South Wales with special reference to soil erosion.* Government Printer, Sydney.

Cooma Rural Land Protection Board (RLPB) 1998. Drought declaration statistics.

Dovers, S. 1986. Investigating landscapes in the Numeralla district of New South Wales. Unpublished thesis. ANU, Canberra.

Hancock, W.K. 1972. *Discovering Monaro: a study of man's impact on his environment.* Cambridge University Press, Cambridge.

Ikerds, J.E. 1996. Assessing the health of agroecosystems: A socioeconomic perspective. Paper presented to the first international ecosystem health and medicine symposium in Ottowa, Canada, 1996.

Jones, R. & Campbell, M. 1998. The economics of serrated tussock in the Monaro: Impact and options to control weed spread. Paper presented to Recovering the Monaro Workshop, August 1998.

Seddon, G. 1994. *Searching for the Snowy: An environmental history.* Allen & Unwin, St Leonards NSW.

# Native grasslands on the Victorian Basalt Plains
## or 'What you value is what you get'

Val Lang

'Titanga', Lismore VIC 3324
vlang@h140.aone.net.au

The original grassy landscapes of the Basalt Plains in Western Victoria were crucial to the success of the pastoralists who started arriving in the late 1830s. The area was settled so successfully and so rapidly that no formal reserves of original vegetation were set aside.

Innovations for increased agricultural production have been a focus in this region since European settlement. The use of fertiliser and introduced pasture species, intensive grazing regimes, and off-site effects such as the invasion of pasture species and weeds into linear reserves have dramatically altered or eliminated the original grassland communities. It is estimated that 99.5% have been destroyed.

Until recently, what remained on linear reserves and on farming properties was more a matter of chance than active planning.

Significant factors are impacting on the remaining, isolated and discrete, populations of plants: there are people with a greater awareness of the grassland heritage and formal support for some conservation initiatives; there is a loss of first hand memory of the Indigenous people as part of the landscape; there are changes in farming practices, with techniques and species allowing increased cropping; there is a change in 'land managers', with more people with urban experience and less young people; and with low commodity prices, there is an increased economic imperative, creating pressure on farmers to define what is of value, assess costs/returns and set priorities, which may or may not consider conservation of the original grassland species.

### Introduction

The original grassy landscapes of the Basalt Plains in Western Victoria were crucial to the success of the pastoralists who arrived in the late 1830s. The area was settled very successfully and rapidly.

I will present a farmer's perspective of the area near Mt Elephant, a volcanic cone surrounded by basalt plains approximately 2 hours drive west of Melbourne.

The 1857 painting by Eugen von Guerard of the early 'Larra' settlement shows an open grassy landscape with low trees along the swampy areas and in the background the volcanic cone of Mt Elephant covered with She-oak, Silver Banksia and Wattle (Oman *et al*. 1961).

By the 1870s there were grand bluestone homesteads built with local basalt, imported timber, and the profit from raising sheep on the excellent native pastures.

Innovations for increased agricultural production have been a focus in this region since European settlement. The use of fertiliser and introduced pasture species, intensive grazing regimes and off-site effects such as the invasion of pasture species and weeds into linear reserves has dramatically altered or eliminated the original grassland communities. It is estimated that 99.5% have been destroyed.

Now you can drive for kilometres without seeing any indigenous vegetation. There are no trees on Mt Elephant. The original forest was harvested for the Derrinallum Butter Factory, burnt in the 1944 fires, and the subsequent re-growth eaten by rabbits. There is still some native grass, and what may be the only remaining tree violet, hidden between some rocks.

## What you see is what you get

There are few community members who remember the trees, so much so that at a meeting where it was suggested that trees be planted on Mt Elephant one local commented that 'maybe that would not look right'.

Other locals, like Arthur Welfare, have included the remnant trees in what they see of the world. Arthur, a farmer, runs a small nursery that features indigenous tree species.

The area was settled so easily and so completely that no formal nature reserves were set aside. What remained on public and private land was mostly by chance.

Chatsworth Road is one example of this. In 1944, wildfires burnt Derrinallum township. Since then, the fire brigade has burnt a strategic fire-break along Chatsworth Road, to the north west of the town, almost every year. This site is now a significant example of basalt plains vegetation. Every year there is an incredibly rich display of wildflowers with, for example, yellow Snake Orchids and Yam Daisies, purple Chocolate Lilies and Swainson Peas and pink Convolvulus.

You can still find small, species-rich sites on public and private land, each with its chance history and its unique suite of plants.

On private land these sites are often 'neglected areas', unimproved pastures or places where the grazing is not too intense and small areas that were too wet or 'over the other side of the creek' and thus missed out when the fertiliser was spread or the pasture species were being improved.

In the Corangamite Catchment area virtually all of the remnant grassland vegetation is recorded as being on private land (Corangamite CMA 1999), a small amount on public land, and a negligible amount, if any, in reserves. The remnants on public land, whilst smaller, tend to contain more rare species and less weed cover than those on private land.

We cannot rely on chance to continue to preserve these areas on private land. Farming practices are changing rapidly and these remnant areas will be greatly affected by new innovations in agriculture.

With new technologies and a different economic climate, there are enormous changes in rural areas; these changes affect both the attitude to land and the actions that are taken.

For the past 100 years, grazing sheep has been an important part of local farming enterprises. These grazing practices have become more intensive with time and there is strong pressure to increase production and to consider other enterprises.

## Sheep farmers are not building bluestone homesteads

The 1997-98 'return to assets' graph from the 1997-98 South West Monitor Farm Project (Patterson *et al*. 1999) analysis illustrates the poor returns from wool farming. The top 20% of farmers are shown to have between 6 and 7% return, while the average return for the sample is about 2.6%.

This information is from 49 farms in South West Victoria, including some near Mt Elephant. These farms, predominantly wool producing properties, were not randomly selected so the data cannot be used to represent overall averages, however, they do indicate a low return to assets for many farmers. The information collected by the South West Monitor Farm Project provides a useful tool for farmers to improve management practices and consider other industry options.

Due to high costs and poor returns, farmers are intensifying production and experimenting with other enterprise options. Changes in technology can be used by farmers to support these changes and to increase economic returns.

Improved management of pastures is an option considered by many farmers. Recent farm records from 'Titanga' (10 km from Mt Elephant) show carrying capacity of native pasture to be 2.5 sheep/ha, with un-managed improved pasture to be 7-8 sheep/ha, and well-managed improved pasture to be 12 sheep/ha.

According to South West Monitor Farm Group data, changing enterprises from wool to hay and cropping can increase the gross margin from $144/ha to $265/ha. So there are strong incentives to consider intensifying production or changing enterprise. This is usually at the expense of the remnant grassland vegetation.

## Some changes and the impact on remnant vegetation

### Herbicide use to allow early burning of fire breaks

This practice has many advantages to the farmer and to the community. The break can then be burnt when the surrounding area is still green, so the risk of wildfire is reduced. The break is more effective because it is put in place early in the fire season. This system needs less labour, which is very important because the number of available volunteers, particularly young people, is declining.

Herbicide can have a disastrous effect on the native vegetation. In some places, the continuance of late burning on recognised sites has worked well, particularly if there is a local person who is concerned about the site. In other areas, however, there can still be over-enthusiastic spraying.

Changed and more intensive landuse can eliminate remaining remnant vegetation unless there is a conscious effort to maintain it.

### Increased cropping

There are new crop varieties that make cropping possible and profitable in this area, e.g. Canola and Red Wheat can now be grown. There are large areas of grazing land being used that have not previously been cropped. With minimum tillage techniques, i.e. greater broadacre use of herbicide and less soil disturbance, it is easier and more economical to put in crops over a greater area. The increased cropping and management to control Serrated Tussock (*Nasella trichotoma*) has increased the removal of rocks. Wetter areas can be cropped by using raised bed cropping.

Other enterprises that have been introduced very quickly, such as Pine or Blue Gum pulp-wood plantations, can be very extensive and all encompassing, with few gaps to allow chance survival of grassland species.

## What you value is what you get

Amongst my farming neighbours many will look at the same situation and see different things.

A waterlogged area, or a wetland? One neighbour saw his swamp as valuable enough to put a Trust For Nature covenant on it before he sold the land.

'Salinity' and a rising water table, or a saline marshland? Another neighbour has just covenanted an area that other farmers consider a wasteland. She values it as a fascinating remnant plant community. She said she thought she should preserve her section of it because none of her neighbours were preserving theirs.

Silver Tussock Grass (*Poa labilliardierei*) can be looked at with suspicion if it is seen as being linked to Serrated Tussock. It may be viewed in a more kindly light if it is seen as part of our ecosystem and plant heritage.

Trust for Nature figures indicate a growing farmer interest in conservation (P. Foreman pers. comm. 1999). This is, however, coupled with the impact of very rapid and broad-reaching effects of changing land management practices and increasing economic pressures.

What you value is what you get. But you do need to have the resources to manage it, this includes financial resources and the information on how to manage a site when the conditions that allowed it to survive until now have been changed.

## References

Corangamite CMA 1999. Corangamite Catchment Management Authority Draft Regional Vegetation Plan.

Oman, J.R., Lang, P. B. & Ryan, J. 1961 (2nd ed). Browns Waterholes History of Lismore 1840-1961. Adams Printers, Geelong.

Patterson, A. P, Beattie, L.M. & Floyd, P. J. 1999. South West Monitor Farm Project, Summary of Results 1997-98. Catchment and Agriculture Services, Dept of Natural Resources and Environment, Hamilton.

# Native grasslands – who needs them?

Owen Whitaker

C/- Gundaroo PO, Gundaroo NSW 2620
gaact@netinfo.com.au

Changes wrought by European-inspired agriculture over the last 150 years have decimated our natural grasslands and grassy woodlands, leaving them at best in a depleted and fragmented state. Current trends in agriculture, global trading policy and consumer expectation can only put more pressure on surviving biodiversity, to the point where much of our farmland may well be best described as industrial rather than rural.

Native grasslands await one of the final indignities—to be confirmed with the status of rare and endangered curiosities, closeted away and protected by well-meaning environmental enthusiasts. Will this ensure their survival? At present in south-eastern Australia's farmlands, there still exist native 'grass-scapes' of sufficient size and diversity to make a significant contribution to agriculture as well as the environment. To survive and improve, the last of these larger remnants must be grazed, burnt and generally managed with due care, consideration and concern. If native grasslands are not regarded as an important grazing resource this management will not occur.

Government initiatives have proven to be potent at changing land management practices and landscapes—the superphosphate bounty is an excellent example, arguably responsible for beginning one of the greatest landscape changes to 'improved' pastures and increasing soil acidity. An action plan is urgently required for restoring our large areas of degraded native grasslands to a condition where they are relevant to today's production systems, while still retaining their biodiversity. Positive extension of native grassland management, in particular the strategic and integrated grazing of 'exotic' and 'native' paddocks, is needed.

Incentives for landholders to undertake better management, especially periods of de-stocking, are crucial. We all may want native grasslands to survive in Australia, but unless our grazing industry sees the need for them they will continue to decline.

Changes wrought by European-inspired agriculture over the last 150 years have decimated our natural grasslands and grassy woodlands, leaving them at best in a depleted and fragmented state.

Current trends in agriculture, global trading policy and consumer expectation can only put more pressure on surviving biodiversity, to the point where much of our farmland may as well be described as industrial rather than rural.

Native grasslands await one final indignity—to be confirmed with the status of rare and endangered curiosities, closeted away and protected by well-meaning environmental enthusiasts. Will this ensure their survival? At present in south-eastern Australia's farmlands there still exist native grass-scapes of sufficient size and diversity to make a significant contribution to agriculture as well as to the environment. To survive and improve, the last of these larger remnants must be grazed, burnt and generally managed with due care, consideration and concern.

If native grasslands are not regarded as important grazing resources, this management will not occur.

It must be acknowledged, however, that native grasslands rarely match exotic pastures for sheer production capacity alone. Instead, they are great landscape strategists with an unmatched genetic capacity to provide, for example:

- economy—with little need for inputs and natural ability for self-propagation;
- stability—through drought, bushfire and short periods of high stocking rates;
- endurance and ability—to thrive in shallow, nutrient-depleted and acidic soils under harsh climatic conditions;

- rapid response—to rainfall, especially during summer when evaporation severely limits growing time available;
- soil conservation—providing the groundcover that protects our most valuable resource from erosion, enhancing the biota living within it, and holding the rain that falls upon it.

It is the strategic use of these natural abilities that will best demonstrate the value of native grasslands to their largest custodian—rural Australians.

The vast majority of our existing native grass-scapes are not managed, they simply survive or slowly decline under a regime of set-stocking and the absence of the vital renewing processes of fire and rest.

The balance, however, are glowing examples of the ability of native grasslands to respond to positive management. Although sometimes management is more accident than by design, we must carefully consider what positive processes are at work and incorporate similar strategies into compatible remnants.

The most important management action any landholder can undertake is also by far the easiest, and simply involves—CLOSING THE BLOODY GATE! I would also recommend this action as vital to evaluating our most common form of native grassland—a degraded one.

Allowing your 'grassy patch' an early spring to mid-summer period without stock should make it pretty obvious which has the 'upper hand'—the weeds or the natives. This action will also allow vital replenishment of the native seedbank, the very foundation for any future management. It can also allow exotics and noxious weeds that are present to achieve the same result. Valuable strategies to prevent this include:

- heavy grazing prior to de-stocking, to suppress early season weeds; and
- patch spraying and/or chipping of noxious exotics and other undesirables.

A decision should be made after a minimum of 2 spring/summer de-stockings as to whether the grassland has the ability to respond to the resources available for management.

My own experience and observation suggests that species-poor, fragmented grasslands competing with exotics on higher quality soils with a history of cultivation and fertiliser are best given over to fodder crops or improved pasture to relieve the stock pressure on higher quality remnants. The intensive inputs that would be required to recover a native grassland system under these conditions would not be economically viable and would result, at best, in an 'engineered' result.

If sufficient numbers and densities of native grassland species begin to wave in the wind and declare 'we're back', the real challenge has begun—to go down the path few have trod before of pro-active grassland management. At this stage, identification of species on-site and an understanding of their individual traits needs to be appraised. These traits include growth patterns, flowering and seeding times, grazing sensitivity, seed dispersion, placement and germination, and suitability for soil type.

By this time, fire management will have become an issue, either as a proactive regenerative tool and/or as a hazard reduction method. In my experience, rotationally grazed and occasionally burnt native grasslands are less of a summer fire risk than exotic annuals, let alone hayed-off winter crops or stubbles. In fact, many of the well-managed native grasslands will be green in summer and yet carry a good fire in the depths of winter. Fire management is far easier than many believe and is part of the intriguing genetic adaptability to the landscape that native grasslands have achieved.

All in all, pro-active management for restoring and maintaining native grasslands is quite simple—simply lock them up from early spring to mid-summer, crash graze them once or twice in between, and toss a match into them every 4 to 5 years. Easy, hey?

NOT!

We are dealing with an extraordinarily complex and sophisticated ecosystem that has adapted in different ways to every soil type, rainfall zone and climatic area that this continent provides. Good, long-term management only comes from living with your grass-scape, observing and understanding its unique identity, sharing this information with others who are doing the same, and applying the knowledge gained to your 'patch'.

As a remnant grassland becomes more robust, variations to the standard practice management are needed, such as occasionally grazing in spring and summer, or when conditions permit a hotter burn in summer. These variations can be incorporated with climatic variables, such as droughts and wet summers, and have the potential to provide strategic use of the area that benefits the rest of the farm.

At this point in time, our gazing industry is undergoing its greatest ever survival challenge. Loss of economic, social and environmental viability has many landholders considering both their future land management and traditional ideals. Changing grazing practices to a cost-effective natural resource management system is a more commonsense option than ever before.

Government initiatives have proven to be potent at changing land management practices and entire landscapes. The superphosphate bounty is an excellent example, arguably responsible for beginning one of the greatest landscape changes with 'improved' pastures and increasing soil acidity. An action plan is urgently required for restoring large areas of degraded native grasslands to a condition where they are relevant to today's production systems, while still retaining their biodiversity. Positive extension of native grassland management, in particular the strategic and integrated grazing of exotic and native paddocks, is needed.

Incentives for landholders to undertake better management, especially periods of de-stocking, are crucial.

We may all want native grasslands to survive in Australia, but unless our grazing industry sees the need for them they will continue to decline.

# Session 3

## Biodiversity of the Grassy Landscape

# Bats in rural landscapes: a significant but largely unknown faunal component

L. F. Lumsden[1] and A. F. Bennett[1, 2]

[1] Arthur Rylah Institute for Environmental Research, Department of Natural Resources and Environment, 123 Brown St, Heidelberg VIC 3084
Lindy.Lumsden@nre.vic.gov.au.
[2] School of Ecology and Environment, Deakin University – Rusden Campus
662 Blackburn Rd., Clayton VIC 3168
bennetta@deakin.edu.au.

The Northern Plains of Victoria, like other agricultural regions of southern Australia, has experienced extensive loss and fragmentation of its native woodlands. Thirteen species of insectivorous bats occur in the area. All are dependent on remnant native vegetation for roosting and foraging. To investigate how these species are distributed throughout the landscape, we sampled 195 sites in remnants of varying size and form. Bats were widespread throughout all remnant types, with at least some activity at every site. In addition to the larger blocks, foraging occurred around individual trees in paddocks, but not in open farmland devoid of trees. Two species were studied intensively to investigate how they used the fragmented landscape. Gould's Wattled Bats (*Chalinolobus gouldii*) roosted predominantly in very large live trees in Barmah State Forest, an extensive floodplain woodland, while foraging up to 11 km away in remnants in farmland. There were differences in the behaviour of males and females of the Lesser Long-eared Bat (*Nyctophilus geoffroyi*). Most males roosted and foraged in relatively small woodland areas in farmland. In contrast, females moved considerably further with most roosting in Barmah S.F. and foraging up to 12 km distant in farmland remnants. Different types of roost were selected by males and females, and during the breeding and non-breeding seasons. Insectivorous bats can consume up to half their body weight in invertebrates in a night and some species feed extensively on agricultural pests. They therefore play an important role in maintaining the health of the rural landscape.

*Keywords: bats, remnant vegetation, nature conservation*

## Bats- a prominent component of the mammal fauna

There are 90 taxa of bats currently known from Australia, which together make up more than 25% of the native mammal fauna (Duncan *et al.* 1999). These species belong to seven families: the Pteropodidae (flying-foxes, fruit-bats and blossom-bats), Megadermatidae (Ghost Bat), Rhinolophidae (horseshoe bats), Hipposideridae (leaf-nosed bats), Emballonuridae (sheathtail bats), Molossidae (freetail bats) and Vespertilionidae (vespertilionid bats). Bats occur in substantial numbers throughout all environments in Australia, from the tropics to the arid deserts, and in most areas constitute a large part of the local mammalian fauna. They are important contributors to a range of ecosystem processes, including seed dispersal, pollination, and predation of invertebrates.

However, other than the flying foxes, which are large and visible in their diurnal roost sites, most species of bats are poorly known and rarely encountered. This is particularly true in temperate environments of southern Australia, where the dominant group of bats are the vespertilionids. These species are all small (4-25 g body weight), nocturnal in activity, and roost during the day in locations seldom seen by most people. They have two main habitat requirements: suitable areas in which to forage for invertebrates; and roost sites (mostly in tree hollows) for diurnal shelter and seasonal reproduction.

The extensive loss and fragmentation of the natural environment in agricultural regions of southern Australia has been well-documented, and the negative effects on many groups of animals are becoming increasingly evident (e.g. Loyn 1987; Saunders 1989; Bennett 1990; Barrett *et al.* 1994). As most species of wildlife cannot survive in cleared farmland, conservation in such regions depends upon the ability of the fauna to use the remaining natural vegetation. Several recent studies (e.g. Lumsden *et al.* 1994; Law *et al.* 1999) suggest that insectivorous bats have a relatively high capacity to persist in heavily disturbed rural environments, at least in comparison with other faunal groups such as terrestrial mammals and woodland birds that have shown marked decline and local extinctions (e.g. Robinson & Traill 1996). There is no evidence that any species of bats have become extinct in south-eastern Australia, although the lack of historic data limits detailed assessment. In this paper, we discuss the status of bats in one such rural environment in south-eastern Australia and summarise aspects of the roosting and foraging ecology of two species amongst remaining woodland vegetation in the area. This information is used to identify a number of important issues in the conservation of remnant vegetation.

## Ecology of bats in the Northern Plains of Victoria- a case study

The Northern Plains is a natural physiographic region in northern Victoria that extends from the inland side of the Great Dividing Range to the Murray River (Fig. 1), forming the Victorian Riverina bioregion (Thackway & Cresswell 1995). It encompasses an area of approximately 22,000 km$^2$ (about 10% of Victoria) and consists of gently sloping floodplains that rarely exceed 150 m elevation. Natural vegetation in this region mainly comprises grassy woodlands dominated by Grey Box (*Eucalyptus microcarpa)*, Yellow Box (*E. melliodora)*, or Black Box (*E. largiflorens)* on the drier plains; and River Red Gum (*E. camaldulensis)* along streams and across floodplains (Bennett *et al.* 1998). Most (>90%) land in the Northern Plains is privately owned and has been extensively cleared for agriculture. Only 1.8% of private land retains tree cover, and this occurs primarily as linear strips along streams, or as small remnants and scattered trees within farm paddocks (Bennett *et al.* 1998). Larger tracts of forest and woodland are located on public land, mainly along the major river systems, such as the Murray, Goulburn and Ovens Rivers. The total extent of tree cover in the region, including these large blocks, is only 6.2% (Bennett & Ford 1997).

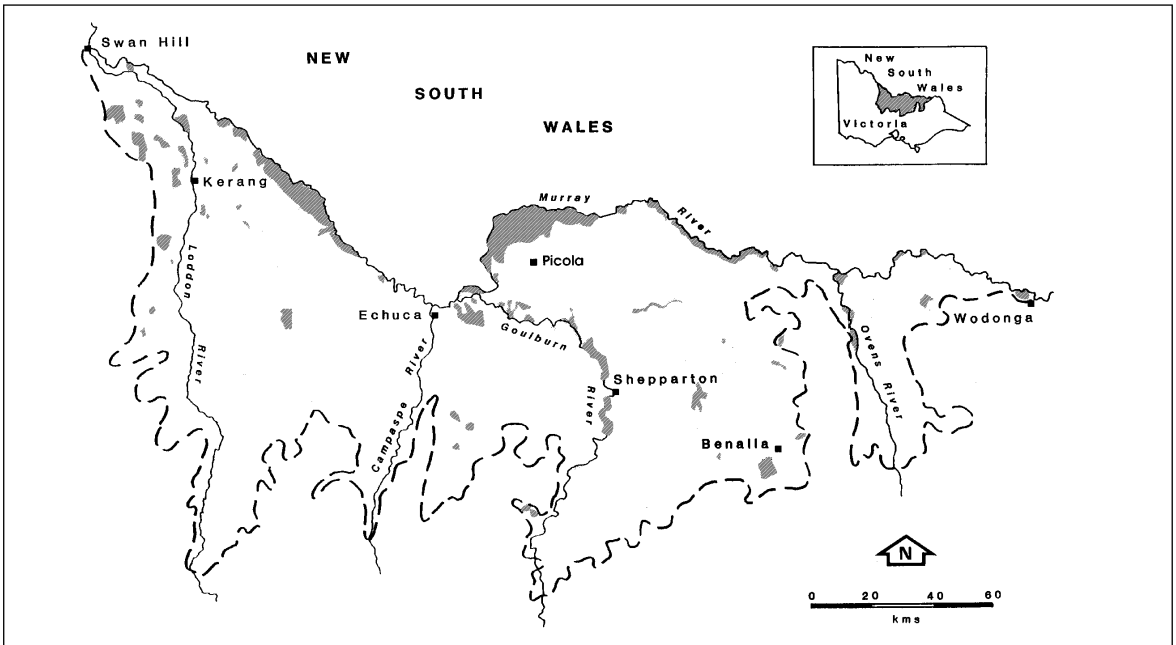



Figure 1. The Northern Plains region of Victoria with areas of remnant woodland shown as shaded.

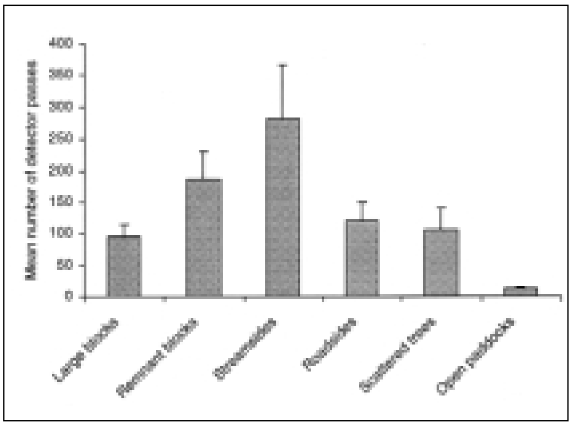



Figure 2. The mean number (± SE) of bat passes recorded by ultrasonic detectors set in remnant vegetation of different forms and sizes in the Northern Plains, Victoria. The number of sites surveyed were: large blocks (>200 ha) n=38, smaller blocks (<200 ha) n=56, streamside vegetation n=40, roadside vegetation n=41, scattered trees n=10, open paddocks n=10.

## Survey of insectivorous bats

As part of a broader research project investigating the distribution and conservation of wildlife within rural environments, we undertook a study of the bat fauna of the Northern Plains (Lumsden *et al.* 1995). Bats were surveyed at 195 sites located across the region, selected to represent different types of remnant woodland vegetation. These included large (> 200 ha) and several size-classes of smaller blocks (5-200 ha), roadside vegetation, streamside vegetation and scattered trees in paddocks. To investigate the dependence of the bats on remnant woodland, sites were also established in open farm paddocks devoid of trees.

The occurrence and abundance of bats at survey sites were assessed using two techniques (Lumsden *et al.* 1995). First, harp traps were set at sites for two consecutive nights to catch bats while they were foraging or commuting from roost sites to foraging areas. This technique allows positive identification of species, plus the collection of information on the age, sex and reproductive status of individuals. Second, ultrasonic detectors, which record the high frequency echolocation calls that bats use for navigation and prey location, were also set at each site. Data from these detectors provides an indication of comparative levels of activity by bats.

More than 1500 individuals of 13 species of insectivorous bats were caught during this study (Table 1). Together, these species comprise 45% of the extant mammalian fauna of the region. The most common species were Gould's Wattled Bat (*Chalinolobus gouldii*), Chocolate Wattled Bat (*C. morio*), Lesser Long-eared Bat (*Nyctophilus geoffroyi*) and Little Forest Bat (*Vespadelus vulturnus),* which together accounted for 60% of captures. Most species were widespread across the region, but two were rare and restricted in distribution. The Southern Myotis (*Myotis macropus)* was limited

Table 1. Insectivorous bats captured during a survey of the Northern Plains, Victoria, and their relative distribution and abundance in the region.

| Common name | Scientific name | No. captures | Distribution and abundance |
|---|---|---|---|
| Southern Freetail Bat | *Mormopterus sp.* | 99 | moderately common and widespread |
| Eastern Freetail Bat | *Mormopterus sp.* | 13 | uncommon but widespread |
| White-striped Freetail Bat | *Tadarida australis* | 24 | common and widespread |
| Gould's Wattled Bat | *Chalinolobus gouldii* | 316 | common and widespread |
| Chocolate Wattled Bat | *Chalinolobus morio* | 230 | common and widespread |
| Southern Myotis | *Myotis macropus* | 1 | rare, restricted to waterbodies |
| Lesser Long-eared Bat | *Nyctophilus geoffroyi* | 264 | common and widespread |
| Gould's Long-eared Bat | *Nyctophilus gouldi* | 39 | uncommon but widespread |
| Greater Long-eared Bat | *Nyctophilus timoriensis* | 1 | rare, only one record for NP |
| Inland Broad-nosed Bat | *Scotorepens balstoni* | 21 | uncommon but widespread |
| Large Forest Bat | *Vespadelus darlingtoni* | 114 | common and widespread |
| Southern Forest Bat | *Vespadelus regulus* | 47 | uncommon but widespread |
| Little Forest Bat | *Vespadelus vulturnus* | 363 | common and widespread |

to areas of permanent water where it forages for aquatic insects and small fish. The Greater Long-eared Bat (*Nyctophilus timoriensis*) is a rare species in Victoria, the individual caught in this study was only the fourth record for the state (Lumsden 1994).

Bats were widespread throughout all types of remnant woodland vegetation. They were trapped at 78% of sites where traps were employed, and their echolocation calls were recorded by ultrasonic detectors at 100% of the survey sites. Using the latter technique, the highest levels of activity were recorded in streamside vegetation and smaller blocks (< 200 ha) of remnant vegetation within farmland (Fig. 2). Activity levels of bats in roadside vegetation and scattered trees in paddocks were similar to those recorded in the larger blocks of forest. The number of bats and the range of species using isolated trees in paddocks was surprisingly high (Fig. 3).

In contrast, the activity of bats in cleared open farmland devoid of trees was much reduced. The few records from these open environments were likely to be from individuals commuting through the area, rather than foraging there. Remnant vegetation, in some form, appears to be necessary for the occurrence of bats in the rural environment.

## Roosting ecology of bats

To investigate the way in which bats use remnant vegetation, two species were selected for detailed studies: the Lesser Long-eared Bat and Gould's Wattled Bat. Both species are relatively common and widespread in rural areas of south-eastern Australia, but little was known about their roosting

Figure 3. Isolated trees within a paddock near Nathalia at which 29 individuals of 7 species were caught in one night.

and foraging requirements. The Lesser Long-eared Bat (7 g body-weight) is a slow-flying, manoeuvrable species (Fig. 4). Prior to this study it was thought to move only short distances (1-2 kms) between roost sites and foraging areas. Gould's Wattled Bat, being larger (14 g) and faster flying, was thought to move greater distances (Fig. 5).

This research was based near Picola, north-east of Echuca, an area used primarily for sheep and wheat farming, in which remnant vegetation is restricted to roadsides and small (i.e. < 10 ha) blocks within paddocks. Approximately 7 km to the north and west is Barmah Forest, an extensive floodplain woodland (29,000 ha) of River Red Gum adjacent to the Murray River. Miniature radio transmitters were temporarily attached to 45 individual Lesser Long-eared Bats and 27 Gould's Wattled Bats. Individuals were trapped at night while they foraged in remnant woodland amongst farmland and then,

Figure 4. Lesser Long-eared Bat (*Nyctophilus geoffroyi*) is a slow-flying species that forages among trees in remnant woodlands in farmland.

Figure 5. Gould's Wattled Bat (*Chalinolobus gouldii*) is one of the most widespread species of bat throughout rural areas of south-eastern Australia.

Figure 6. A typical roost site for a Gould's Wattled Bat, in dead spout on a large old, live River Red Gum.

Figure 7. Although Lesser Long-eared Bats can roost in a range of structures during the non-breeding season, they depend on large dead trees as maternity sites to raise their young. The crack in the middle of this photo contained a maternity roost of females and their young.

during the day, they were tracked back to their roost sites, generally in hollow-bearing trees. Roost trees were identified and measured, and then compared with surrounding trees to determine whether particular types of trees were selected for this purpose. A total of 145 roosts used by Lesser Long-eared Bats and 89 roosts of Gould's Wattled Bat were located. Further details of radio-tracking techniques are provided by Lumsden *et al.* (1994).

Both species of bats were highly selective in the types of roosts used and their location. Selection appeared to occur at four levels: the type of roost cavity occupied, the characteristics of the roost tree, the roost area, and the general position of roost areas within the landscape (Lumsden *et al.* 1994).

The two species selected different types of roost cavities and roost trees. Gould's Wattled Bats favoured large, old, live River Red Gums with a mean diameter of 120 cm. Trees of this size are rare, and were significantly larger than trees in the surrounding area. Roost sites were usually in a dead spout with an opening approximately 9 cm in width (Fig. 6). Colony sizes were mostly between 5 and 20 individuals, although some individuals roosted solitarily. For the Lesser Long-eared Bat, males and females showed marked differences in the types of roost they used. This species had previously been reported roosting in structures of human origin (e.g. sheds, hanging material, fence posts) (Churchill 1998), however, during this study only males roosted in these situations. All roosts used by females were in trees, either under exfoliating bark or in hollows. Maternity roosts, where females give birth to their young, were very specialized—these were located in large old ring-barked River Red Gums (Fig. 7). The roost entrances were narrow cracks in the main trunk (approximately 2.5 cm wide), which presumably opened into a larger chamber capable of housing up to 40 individuals. While the roosts of Gould's Wattled Bats were predominantly in live trees, roosts used by Lesser Long-eared Bats were mainly in dead trees and roosting areas were located in parts of the forest in which there were high densities of dead trees.

Both species moved unexpectedly large distances between roost sites and foraging areas (Lumsden *et al.* 1994). Although initially caught at night while foraging in farmland 7 km from the edge of Barmah Forest, all but one of the Gould's Wattled Bats roosted within Barmah Forest up to 11 km from the point of capture. Males and females of this species behaved in a similar way. In contrast, male and female Lesser Long-eared Bats behaved differently. Most males roosted less than 2 km from their capture point and used a relatively small area for both foraging and roosting. Females, however, moved larger distances with most roosting in Barmah Forest up to 12 km from their point of capture. Even more surprising was the finding that during the breeding season all females roosted in Barmah Forest while foraging in the distant farmland. As females return to the roost several times during the night to suckle their young, it had been expected that they would forage close to their roost to reduce the energetic cost of long flights. However, it appeared that females selected the extensive Barmah Forest as an area for roosting because there were numerous suitable roost trees available, but favoured remnant vegetation amongst farmland for foraging. The benefits of using these separate areas must have outweighed the costs of long flights between them, but the reason why remnant vegetation was favoured for foraging is not yet clear.

Individuals of both species shifted roosts on a regular basis, moving to a new roost every 1-2 days. Subsequent roosts were mostly within 300 m of the previous roost. Bats were faithful to a general roost area, but regularly moved roost sites within that area. This has implications for the number of roosts needed to support an individual or a colony of bats, with possibly as many as 20 or 30 suitable roost trees required in the one area.

Prior to this study there was little concern about the conservation status of either of these species as they were considered to be widespread and common, and non-specific in the types of roosts used. However, it is clear that, in this area at least, they are highly selective in their choice of roosts, particularly during the breeding season. Maternity sites are critical for the survival of young, and so the availability of suitable hollow-bearing trees for maternity roosts is an essential habitat requirement that must be considered.

### Foraging areas and diet

Insectivorous bats are voracious feeders on a range of flying invertebrates and can consume up to half of their body weight in invertebrates in a single night (Hill & Smith 1984). In the Northern Plains, their diet consists mainly of moths, beetles and bugs, with some species also taking spiders, mosquitoes, grasshoppers and crickets (Lumsden 1993).

Foraging activity of bats was concentrated around patches of trees in the landscape, whether in small remnants, along roadsides or streams, or as scattered trees in paddocks. Individuals appeared to have defined foraging areas to which they returned repeatedly. This was particularly evident for Lesser Long-eared Bats. Individuals tagged with radio-transmitters returned to the same foraging area on successive nights, even where these areas were scattered trees in paddocks. Foraging areas were not defended and a number of individuals would use the same site. Trapping results show that, at times, many bats may occur in the same location. In one exceptional example, 600 individuals were caught during a single week of trapping in a 2 km strip of roadside vegetation near Picola. Not all bats that approach a trap are caught, and the success rate may be as low as 10%. This suggests that there are large numbers of bats present in the rural landscape, but because they are highly mobile it is difficult to reliably estimate the density of species (e.g. individuals per $km^2$).

Eucalypt trees host a wide range of insects that defoliate, attack and damage trees in various ways. Rural dieback of eucalypts, for example, is characteristically associated with high levels of defoliating insects and is often more severe in trees amongst grazed pasture than in natural woodlands (Landsberg *et al*. 1990). Birds are important predators of foliage-feeding invertebrates. Ford (1985) estimated that in healthy woodland birds may consume some 55-70% of leaf-eating insects produced annually, thus depressing, if not controlling, insect populations. Many of the insects consumed by bats attack trees during some stage of their life-cycle. Thus foraging by insectivorous bats also has an influence on the mortality of insect populations, and is likely to make an important contribution to the health of remnant trees and woodlands in rural environments. We suggest that predation by bats may be especially important in small remnants and among isolated trees where populations of insectivorous birds are depleted. Woodland birds, such as thornbills, whistlers, treecreepers and robins are frequently absent from small open remnants and scattered stands of trees in the Northern Plains (Bennett *et al.* 1998). However, the presence of canopy trees provides foraging habitat for bats, and their relative mobility means that they can move between a number of such woodlands. Their nocturnal habits mean that they are not excluded by aggressive birds such as Noisy Miners (*Manorina melanocephala*), which contribute to reducing populations of insectivorous birds in small remnants (Loyn 1987; Grey *et al.* 1998).

## Implications for the conservation and management of remnant vegetation

We have synthesized the results of this research to identify a number of points relevant to the conservation and management of remnant vegetation in rural environments.

*1. Bats make an important contribution to the conservation of biodiversity in rural landscapes.*

The abundance and diversity of bats in the landscape is seldom recognised. They are rarely seen because they are active at night and concealed in roosts during the day. In most regions of Victoria bats comprise about one-third of the mammalian fauna, and in extensively cleared regions, such as the Northern Plains, this proportion is higher because a number of terrestrial mammals have disappeared.

*2. All types of remnant forest and woodland vegetation have value for bats.*

Studies of birds and terrestrial mammals in fragmented landscapes have emphasised the importance of larger areas of habitat (e.g. Loyn 1987; Barrett *et al.* 1994; Bennett *et al.* 1998). Small remnants (< 5 ha), linear strips of woodland, and scattered trees in farmland have lower value as habitat for many species, either because the area is too small for a single territory, too small to sustain a population, or because land-use practices such as grazing by stock have degraded the habitat. Bats, in contrast, are mobile and do not need to obtain all of their requirements from a single remnant. They appear to be less sensitive to changes to the ground and shrub layers than are terrestrial mammals and woodland birds, and all types of remnant vegetation have potential value as foraging habitat. In rural environments, where typically 90% or more of the natural vegetation has been cleared and habitat degradation is ongoing, it is important to retain all remnant vegetation. Even isolated trees in open paddocks can be a foraging resource for bats.

*3. Bats have key resource requirements that influence their distribution and abundance.*

The two main resources required by bats are roost sites and foraging areas. Foraging areas are centred on trees, whether in patches, strips, or as scattered trees. Thus, rural landscapes with a substantial proportion of tree cover (e.g. > 10%) are likely to support larger populations than those almost entirely cleared of trees. Bats have specialised requirements for roost sites, especially for maternity roosts during the breeding season. This study has highlighted the importance of large old trees and dead trees as roosts for two common species. Further loss of these types of trees, already scarce in the landscape, will be detrimental to bats.

*4. Key resources may be located in particular parts of the landscape, not evenly distributed throughout. These critical areas need to be identified and protected.*

In this study, key roosting habitat was located within the extensive Barmah Forest in the form of large old trees. Particular trees were selected for maternity roosts by breeding females, and it is likely that the availability of such trees also influences the selection of roosting areas by females outside the breeding season. Remnant vegetation in farmland, while providing foraging habitat, was not favoured for roosting by females of either species. It was, however, used extensively by male Lesser Long-eared Bats. In other areas where there are not adjacent large blocks of forest, roosts are likely to be located within the most suitable remnant vegetation.

*5. Management and conservation in rural landscapes needs to be planned at the landscape scale.*

The mobility of bats and the spatial scale at which they use habitats means that planning for conservation in rural areas needs to be undertaken at the landscape or regional level. A small remnant in farmland is valuable as habitat, but on its own is insufficient to provide for even a single individual let alone the requirements of a population of bats. In this study, individual bats moved up to 12 km between foraging and roosting areas. The area encompassed by a population probably spans tens of thousands of hectares. This has a number of implications. Firstly, remnant vegetation in rural environments occurs on both public and private land—both are important to bats. Planning for conservation at a landscape scale requires integration and cooperation across all land tenures. Secondly, the long-term status of bats and other wildlife is linked to region-wide changes in environmental quality. Processes such as rising saline groundwater, the paucity of tree regeneration on private land, and regional revegetation strategies each have an impact on wildlife habitat and therefore the status of populations in the region.

*6. Habitat restoration and revegetation in rural environments.*

Revegetation is a practical response to problems of land degradation and habitat loss, and is being actively carried out by individuals, groups and Government agencies throughout rural areas of Australia. In most instances, revegetation is carried out for land protection purposes and planted areas are often small and isolated from existing natural vegetation, thus limiting their potential value to many faunal species. However, bats, because of their mobility, are potentially able to use revegetated areas sooner than other animal groups. Such areas may provide foraging habitat long before the trees have grown sufficiently to provide roosting sites.

*7. Bats and other wildlife populations can have a positive role in rural environments.*

Large numbers of bats are present in many rural environments, although estimates of population sizes are still to be made. Foraging bats consume a large number of invertebrates and, like insectivorous birds, influence population sizes of invertebrates. This role has potential benefits for the health of trees and pastures in the rural environment. In the Northern Plains, one species, the Southern Freetail Bat (*Mormopterus sp.*), was found to feed extensively on Rutherglen Bugs (Order Hemiptera), a serious agricultural pest of a range of crops.

*8. Bats can be successfully used to promote the conservation of remnant vegetation.*

The demonstration of bats and bat trapping has proved to be successful as a focus for field days and extension activities promoting the importance of remnant vegetation in rural environments. Bats are poorly known within the general community and, being nocturnal, are seldom seen by landholders. Most people find it fascinating to actually see these small animals close up. They can be portrayed as having a beneficial role in the rural environment because they feed on insects, and they are rarely viewed as having negative impacts.

*9. Conservation in rural environments requires a long-term approach.*

All species of insectivorous bats in the Northern Plains use tree hollows or crevices for roost sites, which most frequently occur in large trees. Large old trees are a scarce resource in this region (Bennett *et al.* 1994) and their scarcity highlights two issues in long-term conservation. First, old trees take many years to develop suitable hollows and such trees are now uncommon in forests managed for timber production. Regenerating trees or those planted as part of revegetation programs will take at least a century to reach a suitable condition. Second, in many areas of remnant vegetation in farmland where old trees are still present, grazing by stock has inhibited regeneration of a new cohort of trees to replace the veterans when they die. A long-term approach is needed to ensure that existing old trees are protected and that adequate measures are taken to ensure an ongoing replacement of hollow-bearing trees through time.

## Acknowledgments

This work was funded by the Department of Natural Resources and Environment and the Australian Nature Conservation Agency's 'Save the Bush' Program. We would like to thank the many landholders who gave us access to their properties; John Silins and Steffan Krasna for assistance with the field work; and Sue Churchill and Richard Loyn for commenting on a draft of this paper.

## References

Barrett, G.W., Ford, H.A. & Recher, H.F. 1994. Conservation of woodland birds in a fragmented rural landscape. *Pacific Conservation Biology* 1: 245-56.

Bennett, A.F. 1990. Land use, forest fragmentation and the mammalian fauna at Naringal, south-western Victoria. *Australian Wildlife Research* 17: 325-47.

Bennett, A., Brown, G., Lumsden, L., Hespe, D., Krasna, S. & Silins, J. 1998. *Fragments for the Future. Wildlife in the Victorian Riverina (the Northern Plains).* Department of Natural Resources and Environment, East Melbourne.

Bennett, A.F. & Ford, L.A. 1997. Land use, habitat change and the conservation of birds in fragmented rural environments: a landscape perspective from the Northern Plains, Victoria, Australia. *Pacific Conservation Biology* 3: 244-61.

Bennett, A.F., Lumsden, L.F. & Nicholls, A.O. 1994. Tree hollows as a resource for wildlife in remnant woodlands: spatial and temporal patterns across the northern plains of Victoria, Australia. *Pacific Conservation Biology* 1: 222-35.

Churchill, S. 1998. *Australian Bats.* Reed New Holland, Sydney.

Duncan, A., Baker, G.B. & Montgomery, N. (eds) 1999. *The Action Plan for Australian Bats* Environment Australia, Canberra.

Ford, H.A. 1985. The bird community in eucalypt woodland and eucalypt dieback in the Northern Tablelands of New South Wales. In: A. Keast, H.F. Recher, H. Ford & D. Saunders (eds) *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management*, pp. 333-40. RAOU and Surrey Beatty & Sons, Chipping Norton.

Grey, M.J., Clarke, M.F. & Loyn, R.H. 1998. Influence of the Noisy Miner *Manorina melanocephala* on avian diversity and abundance in remnant Grey Box woodland. *Pacific Conservation Biology* 4: 55-69.

Hill, J.E. & Smith, J.D. 1984. *Bats, A Natural History.* Rigby Publishers, London.

Landsberg, J., Morse, J., & Khanna, P. 1990. Tree dieback and insect dynamics in remnants of native woodlands on farms. *Proceedings of the Ecological Society of Australia* 16: 149-65.

Law, B.S., Anderson, J., & Chidel, M. 1999. Bat communities in a fragmented forest landscape on the south-west slopes of New South Wales, Australia. *Biological Conservation* 88: 333-45.

Loyn, R.H. 1987. Effects of patch area and habitat on bird abundances, species numbers and tree health in fragmented Victorian forests. In: D.A. Saunders, G.W. Arnold, A.A. Burbidge & A.J.M. Hopkins (eds) *Nature Conservation: The Role of Remnants of Native Vegetation*, pp. 65-77. Surrey Beatty & Sons, Chipping Norton.

Lumsden, L. 1993. Bats, natures nocturnal insect controllers. *Trees and Natural Resources* 35(4): 8-11.

Lumsden, L. F. 1994. The distribution, habitat and conservation status of the Greater Long-eared Bat *Nyctophilus timoriensis* in Victoria. *Victorian Naturalist* 111: 4-9.

Lumsden, L., Bennett, A., Silins, J. & Krasna, S. 1994. Fauna in a remnant vegetation-farmland mosaic: movements, roosts and foraging ecology of bats. A report to the Australian Nature Conservation Agency 'Save the Bush' Program. Flora and Fauna Branch, Department of Conservation and Natural Resources, Victoria.

Lumsden, L.F., Bennett, A.F., Krasna, S.P. & Silins, J.E. 1995. The conservation of insectivorous bats in rural landscapes of northern Victoria. In: A. Bennett, G. Backhouse & T. Clark (eds) *People and Nature Conservation: Perspectives on Private Land Use and Endangered Species Recovery*, pp. 142-8. Royal Zoological Society of New South Wales, Sydney.

Robinson, D. & Traill, B.J. 1996. Conserving woodland birds in the wheat and sheep belts of southern Australia. *RAOU Conservation Statement* No. 10.

Saunders, D.A. 1989. Changes in the avifauna of a region, district and remnant as a result of fragmentation of native vegetation: the Wheatbelt of Western Australia. A case study. *Biological Conservation* 50: 99-135.

Thackway, R. and Cresswell, I.D. (eds) 1995. *An Interim Biogeographic Regionalisation for Australia: A framework for setting priorities in the National Reserves System Cooperative Program*. Australian Nature Conservation Agency, Canberra.

# Plains-wanderers, native grasslands and biodiversity

David Baker-Gabb

Elanus P/L
24 Alexandra Street, Greensborough VIC 3088
elanus@bigpond.com

Birds can be useful indicators of habitat quality and can lead to the location of threatened habitat. Moreover, birds can provide insights into the best management regimes for threatened habitat.

Searches for the nationally vulnerable Plains-wanderer (*Pedionomus torquatus*), a small, cryptic bird that is endemic to eastern Australia's grasslands, can be like searching for the proverbial needle in a haystack. A significant side benefit of surveys for Plains-wanderers over the past decade has been the location of many formerly unknown sites with threatened grassland plants. Included among these 'haystacks' are such gems as the recent additions to Terrick Terrick National Park in north-west Victoria, and newly acquired Astrebla National Park in western Queensland.

Plains-wanderers coexist with light grazing, but they cannot persist in areas that are overgrazed. They are eliminated when their sparse native grasslands are converted to crops or dense introduced pasture. Hence they have been extirpated from the coastal and sub-coastal regions of the four eastern mainland States. The Riverina of NSW is now the core of the species' distribution. With the decline of the wool industry, there are significant moves towards cultivation and cropping of native pastures. In the path of this development push is recent NSW legislation concerning threatened species (1995), clearing native vegetation (1997) and the Plains-wanderer. The Plains-wanderer has become both a conservation 'flagship' for native grasslands, and a target for landholder invective concerning government interference on freehold land. The recently formed Plains-wanderer Recovery Team has significant challenges ahead.

*Keywords: Plains-wanderers, grassland, conservation*

## Introduction

The lowland native grasslands of temperate south-eastern Australia have been drastically altered and depleted owing to their suitability for, and sensitivity to, agriculture. As their habitats have been changed or lost, threatened grassland fauna such as the Plains-wanderer (*Pedionomus torquatus*) have also declined.

The endangered Plains-wanderer is a small ground-dwelling bird of sparse native grasslands (Baker-Gabb *et al.* 1990). It is an inland shorebird that superficially resembles button-quail (*Turnix* species). Both the male and female have cryptic plumage with the female being larger and more brightly coloured than the male (Marchant & Higgins 1993). The Plains-wanderer is of great scientific interest, being the sole member of a family of birds found only in south-eastern Australia. It may be an ancient member of Australia's avifauna, and its closest relatives are seedsnipe (*Thinocorus* species) which are South American inland shorebirds (Olson & Steadman 1981; Sibley *et al.* 1988).

## Plains-wanderer status and distribution

The Plains-wanderer has declined greatly in numbers and distribution since European settlement (Llewellyn 1975; Bennett 1983; Blakers *et al* 1984). Areas where the Plains-wanderer was formerly common and is now effectively extinct include south-western Victoria, south-eastern South Australia and eastern New South Wales (Bennett 1983; Webster 1996a, 1996b). Their current stronghold is the Riverina of south-western New South Wales (Bennett 1983; Baker-Gabb *et al.* 1990).

Areas of secondary importance include north-central Victoria and central-western Queensland. A viable population does not occur in any reserve, though comprehensive surveys have yet to be conducted in the 200,000 ha Astrebla National Park in central-western Queensland where the species is recorded (Baker-Gabb 1990a).

Surveys conducted over the past 16 years have shown that numbers of Plains-wanderers on the Riverine Plain can vary by a factor of ten (one bird per 2.2 to 20 $km^2$), depending on seasonal conditions, stocking rates and the time of the year when the survey was conducted (Maher & Baker-Gabb 1993; Maher 1997). Suitable habitat comprises about 5% of grazing properties surveyed in the Riverina covering over 0.5 million hectares (Maher 1997). However, the amount of suitable habitat drops to around 1 to 2% in very wet or dry years when the grasslands become too dense or are grazed too bare to suit Plains-wanderers. Recent intensive ground surveys indicate that earlier estimates of 5,500 Plains-wanderers in the Riverina represent the maximum number after several years of ideal conditions. In very dry years, when most birds disperse or perish, the number in the Riverina could drop to around 1,000 mature individuals. The new IUCN criteria determine that the species' status in New South Wales is endangered and it is about to be reclassified as nationally endangered (S. Garnett *in litt.*).

Victoria and South Australia contained perhaps the greatest numbers of Plains-wanderers at the time of European settlement (Bennett 1983; Maher & Baker-Gabb 1993), but nearly all native grasslands in these States have been converted to dense introduced pasture or croplands. Recent comprehensive surveys show that the species is now critically endangered in both these States (Maher & Baker-Gabb 1993; Webster 1996a, 1996b). There are fewer than 500 Plains-wanderers in north-central Victoria, with about 25% of these birds on just one property (Maher & Baker-Gabb 1993). In south-western Victoria and south-eastern South Australia there are no viable populations, with the plains south and east of the Flinders Ranges probably containing only a few birds (Webster 1996b).

An accurate total estimate of Plains-wanderer numbers is difficult to obtain for the whole of south-eastern Australia. Nevertheless, recent surveys show that previous estimates, though possibly accurate when they were made over a decade ago, are now too optimistic. Habitat destruction has continued apace (Webster 1996a, 1996b) and the total number of birds must be revised down by 30% to a maximum of about 8,000 after several good seasons and a minimum of 2,500 in very dry years.

## Habitat requirements

Areas favoured by Plains-wanderers are hard red-brown earths with a sparse covering of native herbs and grasses. Such areas contain about 50% bare ground with fallen litter making up a further 10% (Baker-Gabb 1987, 1990b). The more robust plants in the flora are generally spaced 10-20cm apart and rarely exceed 30cm in height. The bulk (94%) of the vegetation is less than 5cm high, but the small proportion above this height is important for concealment from predators. In the Riverina, pairs of Plains-wanderers occupy home ranges averaging 12 ha (Baker-Gabb *et al* 1990). These favoured 'habitat islands in a sea of denser grasslands' extend over 50-600 ha each, comprise on average 5% of surveyed properties, and rarely exceed 15% of any one property (Baker-Gabb *et al.* 1990; Maher 1997).

The grasslands of the Riverine Plain are considered to be disclimax, the consequence of grazing by domestic stock and rabbits over the past 150 years (Moore 1953a, 1953b). The original climax communities were dominated primarily by Boree (*Acacia pendula*), Old Man Saltbush (*Atriplex nummularia*) and Bladder Saltbush (*A. vesicaria*), with grasses in between. Plains-wanderers were commonly found in this saltbush habitat in the 1800s (North 1913), indicating some resilience and flexibility in their habitat selection.

Areas containing Plains-wanderers often have threatened grassland plants as well as shrublands (Maher & Baker-Gabb 1993; Maher 1997). However, the grasslands with the most threatened plants often occur on ungrazed roadsides, rail lines and cemeteries that have had little or no grazing by stock. These small, high quality remnants are vital for the conservation of grassland plants and invertebrates, even though they are usually too small to support viable populations of Plains-wanderers. Plains-wanderers are also occasionally found in cereal stubble and some low crops. These are similar in structure to sparse grasslands, but offer Plains-wanderers only a temporary, sub-optimal refuge until they are cultivated again.

## Forced movements

In areas that are not cultivated, overgrazed or burnt, population turnover is low, with at least some birds being year-round residents. There is no evidence for regular migration or nomadism by Plains-wanderers, but clear evidence exists for mass movements forced on Plains-wanderer populations by cultivation and overgrazing (Bennett 1983; Harrington *et al.* 1988; Baker-Gabb *et al.* 1990). Those Plains-wanderers that are forced to leave do not return (Baker-Gabb *et al.* 1990), though other birds may occupy these same overgrazed areas when seasonal conditions improve and the grass regrows. Once grasslands are cultivated, however, they remain unsuitable for decades, even if left to recover. Plains-wanderers may also leave when unusually heavy winter rains promote dense growth of introduced and some native plants (Maher 1997). By contrast, heavy summer rains promote the growth of different species of native grasses that do not become too dense for Plains-wanderers.

## Diet

Plains-wanderers forage during the day for a wide variety of seeds and ground-dwelling insects (Baker-Gabb 1988). Grass and saltbush seeds are more important than those of other types of plants. Beetles, ants, sucking bugs and caterpillars are the most frequently taken insects. In all seasons, except in spring when their contribution is slightly higher, insects comprise about 40% of the diet.

## Breeding

Plains-wanderers' nests are shallow grass-lined scrapes in the same sparse grasslands where they forage (Harrington *et al.* 1988). In the southern part of their range, they lay first clutches mainly between August and early November and second clutches in January or later if summer rains fall. In central-western Queensland, Plains-wanderers are known to breed in autumn and early winter (Baker-Gabb *et al.* 1990). Plains-wanderers have the ability to recover quickly from low population levels following droughts (Harrington *et al.* 1988) and can breed in their first year (Ridley 1986; Baker-Gabb *et al.* 1990). They lay 2-5 eggs per nest (Bennett 1983) and raise broods of 2-4 young to independence. In the 16 years since 1981, Plains-wanderers failed to breed in the Riverina during two drought years (1982/83 and 1994) and bred with little success in three wet years (1990-92) (Maher 1997).

Some female Plains-wanderers probably mate serially with two males (Baker-Gabb *et al.* 1990; Marchant & Higgins 1993). Males do most of the incubation and all of the brooding and guarding of chicks, which is unusual among birds. Chicks achieve independence about two months after hatching. Adults may nest in the same areas in consecutive years (Baker-Gabb *et al.* 1990).

## Mortality

It is not known how long Plains-wanderers survive in the wild, but they can live for at least 8 years in captivity (Baker-Gabb 1998). Overgrazing, cultivation, dense pasture growth and fires displace large numbers of Plains-wanderers, which either die or disperse (Baker-Gabb *et al.* 1990). Some of them may be taken by aerial predators because they are more vulnerable on bare ground (Baker-Gabb 1987, 1988). Birds of prey, foxes and quail shooters are all known to kill Plains-wanderers occasionally (Bennett 1983; Baker-Gabb 1998; Marchant & Higgins 1993), but their impact on Plains-wanderer populations is likely to be small compared to habitat changes. Little is known about the impact of pesticides such as fenitrothion, which is periodically sprayed from the air onto plague locusts at concentrations that could kill birds in a large portion of the Plains-wanderer's range (Pearce 1971; Symmons 1985; Baker-Gabb 1987).

## Conservation and management goals for the next five years

The reason for the huge loss of biodiversity from coastal and sub-coastal regions in all four of the Plains-wanderer's range States is cultivation for crops and dense introduced pastures across a vast area of practically all suitable native grasslands. Cultivation has forced conservation efforts for the Plains-wanderer to inland grazing areas. Specifically, the focus has shifted to relatively small areas on the plains near the southern Flinders Ranges of South Australia and around Mitiamo in north-central Victoria, and to much larger areas in the Riverina of New South Wales and in central-western Queensland. The goals in these areas should be to:

1. Maintain the extent and enhance the quality of known Plains-wanderer habitat. The easiest way to enhance habitat quality for Plains-wanderers on the Riverine Plain is to keep stocking rates low (e.g. one sheep per 3 acres or 1.2 ha) during the Plains-wanderer's early August to November

breeding season. This coincides with peak native grassland flowering. If a dry spell persists then grazing pressure should be cut back (e.g. one sheep per 5 acres or 2 ha), particularly during autumn to ensure that some ground cover remains and Plains-wanderers are not forced to leave or perish.

2. Locate and protect Plains-wanderer habitat in areas not yet surveyed. Priority areas for survey include: central-western Queensland, parts of the Riverina in New South Wales, and north-east South Australia.
3. Determine the impact of locust spraying on Plains-wanderers.
4. Negotiate private reserves, ensuring that Plains-wanderer habitat is not cultivated, has at least a 2 km buffer from cultivated land, is not overgrazed during droughts, and is integrated into a regional vegetation plan to avoid isolation.
5. Halve the decline in Plains-wanderers due to overgrazing during droughts by negotiating with landholders to have 10,000 ha of habitat managed as lightly grazed private reserves for the species in both Queensland and New South Wales, and 2,500 ha managed in this way in Victoria and South Australia. This measure could also increase the population of Plains-wanderers by up to 5,000 individuals because carrying capacity can be doubled with optimum management.
6. Establish at least one large conservation reserve in the Riverina of 20,000 ha or more and containing not less than 5,000 ha of habitat suitable for Plains-wanderers. The native grasslands of the Riverine Plain are not adequately represented in the national reserve system.
7. Monitor the impact of management regimes in all States. Terrick Terrick National Park provides an ideal opportunity for experiments and monitoring of the management requirements of a range of threatened grassland flora and fauna.
8. Continue grassland extension programs and provide incentives for landholders. Ensure landholders are involved in decision-making processes.

## References

Baker-Gabb, D.J. 1987. The Conservation and Management of the Plains-wanderer *Pedionomus torquatus*. World Wildlife Fund Report No. 49, 140 pp. World Wide Fund for Nature, Sydney.

Baker-Gabb, D.J. 1988. The diet and foraging behaviour of the Plains-wanderer *Pedionomus torquatus*. *Emu* 115-18.

Baker-Gabb, D.J. 1990a. An annotated list of records of Plains-wanderers *Pedionomus torquatus*, 1980-1989. *Australian Bird Watcher* 13: 249-52.

Baker-Gabb, D.J. 1990b. The biology and management of the Plains-wanderer *Pedionomus torquatus* in NSW. NSW NPWS Species Management Report No. 3. NSW National Parks and Wildlife Service, Sydney.

Baker-Gabb, D.J. 1998. Native grasslands and the Plains-wanderer. Birds Australia Conservation Statement No. 1. *Wingspan* 8(1).

Baker-Gabb, D.J., Benshemesh, J. & Maher, P.N. 1990. A revision of the distribution, status and management of the Plains-wanderer *Pedionomus torquatus*. *Emu* 90:161-8.

Bennett, S. 1983. A review of the distribution, status and biology of the Plains-wanderer *Pedionomus torquatus*. *Emu*: 1-11.

Blakers, M., Davies, S.J.J.F. & Reilly, P.N. 1984. *The Atlas of Australian Birds*. Melbourne University Press, Melbourne.

Harrington, G.N., Maher, P.N. and Baker-Gabb, D.J. 1988. The biology of the Plains-wanderer *Pedionomus torquatus* on the Riverine Plain of New South Wales during and after drought. *Corella* 12: 7-13.

Llewellyn, L.C. 1975. Recent observations of the Plains-wanderer with a review of its past and present status. *Emu* 137-42.

Maher, P.N. 1997. A Survey of Plains-wanderers *Pedionomus torquatus* and native grasslands on the Riverine Plain, New South Wales. Unpublished Report to Birds Australia, Melbourne. 62pp, 15 maps.

Maher, P.N. & Baker-Gabb, D.J. 1993. Surveys and conservation of the Plains-wanderer in northern Victoria. *ARI Technical Report No. 132*. DCNR, Melbourne.

Marchant, S. & Higgins, P.J. 1993. *Handbook of Australian, New Zealand and Antarctic Birds. Volume II, Raptors to Lapwings*. Oxford University Press, Melbourne.

Moore, C.W.E. 1953a. The vegetation of the south-eastern Riverina, New South Wales. I. The climax communities. *Australian Journal of Botany* 1: 485-547.

Moore, C.W.E. 1953b. The vegetation of the south-eastern Riverina, New South Wales. I. The disclimax communities. *Australian Journal of Botany* 1: 548-567.

North, A.J. 1913. *Nests and Eggs of Birds found Breeding in Australia and Tasmania*. The Australian Museum, Sydney.

Olson, S.L. & Steadman, D.W. 1981. The relationships of the Pedionomidae (Aves: Charadriiformes). *Smithsonian Contributions to Zoology* 337: 1-25.

Pearce, P.A. 1971. Side effects of forest spraying in New Brunswick. *Transactions of the 36th North American Wildlife Conference*, pp163-170.

Ridley, E. 1986. Plains-wanderer Project Report 1985. *Bird Keeping in Australia* 29: 115-18.

Sibley, G.C., Ahlquist, J.E. & Monroe, J.R. 1988. A classification of the living birds of the world based on DNA-DNA hybridisation studies. *Auk* 105: 409-23.

Symmons, P. 1985. Locusts, the plague of '84. *Australian Natural History* 21: 327-30.

Webster, R. 1996a. Survey and conservation of the Plains-wanderer *Pedionomus torquatus* on the Western Plains of Victoria. Unpublished report to RAOU, Melbourne. 14pp, 11 maps.

Webster, R. 1996b. Survey and conservation of the Plains-wanderer *Pedionomus torquatus* in south-east South Australia. Unpublished Report to RAOU, Melbourne. 18pp, 13 maps.

# Sun Moths in the back paddock

Fabian Douglas

P0 Box 37, Rainbow VIC 3424

*Keywords: Castniidae, parthenogenetic, moth*

The genus (*Synemon*) to which the Pale Sun Moth (*S. selene*, Lepidoptera: Castniidae) belongs is endemic to Australia. It contains 44 known species, of which 20 are undescribed (Edwards pers. comm.). These diurnal moths are usually brightly coloured, have broad wings, clubbed antennae and strongly resemble butterflies. *Synemon* females have very long retractable ovipositors with which they deposit their eggs underground, at or near the base of their larval host plants. The larvae construct subterranean tunnels and feed on the roots, or with some species the rhizomes, of the host plant. The plants that are selected as larval food by the *Synemon* species are invariably monocotyledons belonging to the families Poaceae, Xanthorrhoeaceae, Cyperaceae and Juncaceae. Pupation occurs within the final larval gallery and the empty pupal shell protrudes from the ground after the adult moth has emerged. It is likely that the larval host plant of the Pale Sun Moth is *Austrodanthonia setacea*, but this has not yet been confirmed beyond doubt. The life cycle of most of the *Synemon* species probably takes at least two years as Common and Edwards (1981) found that *Synemon magnifica* (a species that is fairly typical of the genus) requires two to three years to complete a single generation.

The sun moths (family Castniidae) are a part of the Australian fauna that has a Gondwanan origin. This is clearly illustrated by the worldwide distribution of the family, which is well represented in the Neotropical region (mostly South America) by 81 species belonging to 32 genera. These are listed by Lamas (1994). Surprisingly, two sun moth species belonging to the genus *Tascina* occur in south-east Asia (Common 1990). So far as is known, the Castniidae are absent in Africa, Europe and the greater part of Asia. It is also significant that all of the Australian species are placed in a single genus, appear to be monophyletic, and may be closely allied to the ancient Gondwanan stock. Common (1990) states that there is little doubt that the family was widely distributed in Gondwana before Australia finally rifted from Antarctica and South America, during the early Tertiary about 50 million years ago. It seems likely that the two south-east Asian species have an Australian origin and colonised their present distributions after Australia (? and some of its offshore islands) came into contact with the Sunda Island system during the Miocene, about 20 million years ago.

The Pale Sun Moth is an endangered grassland species of special interest. It was first described by Klug in 1850 and subsequently by Swinhoe in 1892 as *Synemon adelaida*. So far as is known, the Pale Sun Moth is restricted to South Australia and Victoria. In South Australia (where now extinct) it occurred near Two Wells and possibly at Lyndoch. Within Victoria, a few extant populations occur in the Wimmera area and near Mitiamo and Borung on the Northern Plains.

Despite the fact that this species has been known to exist for a considerable time, it has only recently been discovered that some of the Victorian populations are parthenogenetic, with strong circumstantial evidence to suggest that the remaining (Victorian) populations are also parthenogenetic. Of further interest is that within these Victorian populations there are five distinct morphs or forms that appear to be genetically isolated from one another. At some localities in the Wimmera area two or three of the different morphs have sympatric occurrences. To my knowledge, a male of this species has never been recorded or collected in Victoria. Curiously, the South Australian population that formerly occurred near Two Wells was normal with an approximately equal ratio of males to females being collected historically. As would be expected in a normal population (with males) the genetic interchange between individuals ensured that there was a certain amount of variability. This is clearly evident taxonomically in the Two Wells specimens, which are either of a light, intermediate or dark colouration.

The Pale Sun Moth seems to have died out in South Australia as a result of habitat loss due to the widespread ploughing or cultivation that has taken place throughout the Two Wells area where it seems that the main population occurred. Within Victoria the species has managed to survive in several relatively small areas of natural habitat that have never been ploughed. Further, it seems that a medium level of grazing (or periodic high mowing or perhaps burning) is required for populations of the Pale Sun Moth to flourish. In the absence of grazing, the *Austrodanthonia* grassland habitat appears to become overgrown with other competing grasses that are unsuitable as larval hosts. In addition to this, the moths seem to prefer an open microhabitat for basking and oviposition. The Victorian remnants where the species still occurs indicate that both grassland and open grassy woodland are suitable habitats, so long as they contain areas that are dominated by *Austrodanthonia* species.

The conservation values of the Pale Sun Moth cannot be overemphasised as, so far as is known, it is unique within the family Castniidae. This being due to the fact that it has evolved entirely parthenogenetic populations, which are taxonomically distinct from one another. In addition to this, there is scope for some especially interesting studies on the genetics of this species, particularly if all five of the Victorian parthenogenetic morphs can be conserved in perpetuity and a population with males can be rediscovered. At present, the two most urgent conservation priorities that concern the Pale Sun Moth are as follows:

(a) to adequately protect and manage a small site on private land at Nhill in Victoria that is the only known locality where one of the parthenogenetic morphs occurs; and

(b) to conduct surveys in suitable areas of remnant habitat in South Australia to determine if a population with males is still extant.

Surveys for populations of the Pale Sun Moth should be carried out from mid-February to early March, as over 90% of the historic and contemporary specimens have been collected during this time of the year. Characteristics to look for to identify this species are: a wingspan of about 4.5cm; a relatively slender (butterfly-like) body and clubbed antennae; forewings cryptically coloured above and creamy-orange with a few blackish markings beneath; hindwings greyish-black with yellowish-orange markings above and creamy-orange with blackish markings beneath; and a rapid, slightly undulating flight pattern with the wings kept continuously in motion. The Pale Sun Moth is diurnal and only flies when the sun is shining. When at rest, the moths brightly coloured hindwings are usually concealed by the cryptically coloured uppersides of the forewings, which harmonise perfectly with the surrounding debris and dry grasses.

If a population of the Pale Sun Moth is located, it would be greatly appreciated if specimens or photographs could be forwarded to the author at the address given above and also to Mr E. D. (Ted) Edwards at the CSIRO Division of Entomology, GPO Box 1700, Canberra ACT 2601. It is essential to include the relevant data with any specimens (or photographs), including precise locality and date of capture and name and address of collector.

## References

Beauglehole, A.C. & H. M. 1987. *The Distribution and Conservation of Vascular Plants in the Wimmera Area, Victoria.* Western Victorian Field Naturalists Club, Portland, Victoria.

Common, F.B. 1966. *Australian Moths*. Jacaranda Pocket Guides. The Jacaranda Press, Brisbane.

Common, F.B. 1990. *Moths of Australia*. Melbourne University Press, Carlton, Victoria.

Common, F.B. & Edwards, E. D. 1981. The life history and early stages of *Synemon magnifica* Strand (Lepidoptera: Castniidae). *J. Aust. Ent. Soc.* 20: 295-302.

D'Abrera, B. 1974. *Moths of Australia*. Landsdowne Press, Melbourne, Victoria.

Douglas, F. 1993. The Conservation Status, Distribution and Habitat Requirements of Diurnal Lepidoptera in Central and Western Victoria (Part 1: Family Castniidae). Unpuplished report, Department of Natural Resources and Environment, Victoria.

Lamas, G. 1994 (Set. 1995). A critical review of J.Y. Miller's Checklist of the Neotropical Castniidae (Lepidoptera). *Revista Peruana De Entomologia* 36: 73-87.

Marriott, N. & J. 1998. *Grassland Plants of South-Eastern Australia.* Bloomings Books, Hawthorn, Victoria.

# Conservation Management Networks – a model for coordinated protection and management of remnant vegetation

K.R. Thiele and S.M. Prober

Centre for Plant Biodiversity Research
GPO Box 1600, Canberra ACT 2601
kevin.thiele@pi.csiro.au

Grassy box woodlands are one of the most threatened ecological communities in eastern Australia. Occurring on fertile soils in the wheat-sheep belt, very few areas of these woodlands remain little-modified by farming practices. Existing remnants occur on a variety of tenures and in a variety of conditions. A few country cemeteries contain small near-original remnants, while other remnants on private lands, roadsides and travelling stock reserves are often larger and better wooded, but are usually more highly disturbed, with more weeds and fewer native species. Remnants vary in size, but the least disturbed are invariably small. We need to conserve these remnants for many reasons, but we also need to increase the number and improve (restore) the quality of remnants if we are to protect this important ecosystem. These goals can only be effectively achieved through partnerships between tenure-holders, community groups and government at all levels. In NSW, this partnership is being effected using a new model—Conservation Management Networks—for conservation of fragmented ecosystems.

## Introduction

Many ecological communities in Australia are represented by fragments or 'islands' scattered across the landscape. Some, such as wetlands and rainforests, may be naturally fragmented, while others have become so following European agricultural development. In southern Australia, the most severely fragmented and depleted ecosystems are grasslands and grassy woodlands.

Grassy woodlands in south-eastern Australia once covered large continuous tracts, especially on the gently sloping western fall of the Great Dividing Range and adjacent plains areas. They are now reduced to small, more or less isolated remnants in a largely agricultural landscape. All the main grassy woodland communities of south-eastern Australia, from the Red Gum-Yellow Box woodlands of the tablelands to the Bimble Box woodlands of the western plains, are in a similar predicament and urgently require effective conservation and management plans to arrest, and perhaps reverse, their decline.

We have studied one of these woodlands, the grassy White Box woodlands, for the past decade. Previous papers have dealt with the history (Prober & Thiele 1993), floristics (Prober 1996), genetics (Prober & Brown 1994; Prober *et al.* 1998) and management (Prober & Thiele 1995) of these woodlands. More recently (see Thiele & Prober 1999), we have begun using them as a model system for planning and implementing a conservation network that will help address the conservation needs of these and other fragmented ecosystems. This paper describes the conservation needs and status of the grassy White Box woodlands, and outlines a model, the Conservation Management Network[1], being developed and implemented to help protect and manage them.

[1] Called a Protected Network Area in Thiele and Prober (1999).

## The Grassy White Box Woodlands

Grassy woodlands dominated by White Box (*Eucalyptus albens*) once covered several million hectares in the eastern part of what is now the wheat-sheep belt of NSW, with extensions into adjacent areas of Queensland and Victoria. These woodlands occurred on the gently undulating inland slopes of the Great Dividing Range, on relatively fertile soils. They were replaced to the east and in areas of deeper soils of valley floors by grassy Red Gum-Yellow Box (*E. blakelyi*-*E. camaldulensis*-*E. melliodora*) woodlands, and to the west on the plains by Grey Box (*E. microcarpa*) and Bimble Box (*E. populnea*) woodlands. On steeper slopes and poorer soils, woodlands and other eucalypt communities with shrubby rather than grassy understoreys dominated. These are better conserved than the grassy woodlands as they occur on less productive country, and are not considered further here.

Understoreys of the grassy White Box woodlands were mostly dominated by the perennial tussock grasses Kangaroo Grass (*Themeda triandra*) and Snow Grass (*Poa sieberiana*), with other grass species becoming more prominent in the north (e.g. *Dichanthium sericeum*) and on poorer soils (e.g. *Aristida ramosa, Stipa scabra*). Spaces between the tussocks supported a wide variety of other grasses and flowering herbs, particularly daisies and tuberous lilies. Shrubs occurred only sparsely, and tree canopies were widely spaced.

Because the grassy woodlands occurred on relatively fertile soils, they were very quickly taken up for agriculture after Europeans first expanded from the coast and crossed the Great Dividing Range (Prober & Thiele 1993). Virtually all areas have now been grazed or cropped, activities that have had a more or less disruptive effect on the understorey.

Remnants today occur in various forms and under a variety of tenures, including: isolated trees or small stands of trees in grazing or cropping paddocks; linear strips along roadsides, rail easements and Travelling Stock Routes; and small or large patches in country cemeteries, Travelling Stock Reserves, back paddocks on grazing properties, town commons and (occasionally) in State Forests and Nature Reserves.

Remnants differ in the quality and diversity of the understorey and the integrity of the overstorey. A high quality understorey is one with many native plants and few weeds or introduced pasture species. Poor quality understoreys have few natives and/or many weeds or pasture species. In general, understorey quality decreases with increased disturbance from grazing or ploughing. Cemetery sites and some rail easements that have never been grazed or ploughed have the highest quality understoreys, paddocks that have been continuously grazed or cropped have the lowest quality understoreys, while lightly or intermittently grazed paddocks and Travelling Stock Reserves have understoreys of intermediate quality.

The cemetery and railway sites with the highest quality understoreys are invariably small (less than 6 ha). Despite having poorer quality understoreys, larger sites (such as farm paddocks, Travelling Stock Reserves and town commons) are important for other values, particularly as habitat for larger fauna such as birds, and for their landscape values.

## Two models of conservation in Australia

Conservation of any natural ecosystem or area has two linked aspects; protection and management. In Australia, conservation has been historically seen as the domain of government agencies, mostly at the state level, but with important roles also for federal and local government. Non-government and community groups have played an important role in lobbying governments to protect and manage particular areas, but have rarely played a more direct role.

The dominant role of government and the lobbying role of community groups has seen the development of a model of conservation that has concentrated on acquisition by State conservation agencies of pristine areas for National Parks and other nature reserves. Under this model, success of conservation is seen as an increasingly comprehensive system of such acquired and protected areas.

The National Parks model of conservation has been extremely important in protecting many significant areas. It has, however, largely failed to address the conservation needs of highly fragmented communities, such as the grassy woodlands, for several reasons. Firstly, its reliance on acquisition, along with some historical and social imperatives, has seen a concentration of effort on areas that are large, contiguous, scenically spectacular, geographically remote and/or useless for other purposes. Indeed, many people see conservation and spectacular National Parks as almost synonymous. Secondly, the central role of government has been viewed by some local communities with suspicion, and this, along with the bureaucratic structure of the government conservation agencies, has worked against the development of partnerships and strong links with local communities and managers. Thirdly, there has been growing recognition that conservation extends ‘off-reserve’—beyond National Park boundaries—and that all areas, including farms and roadsides, contribute to conservation even if they are managed primarily for other purposes.

Partly because of the failures of the National Parks model with respect to fragmented communities, and partly because of the shift of emphasis towards off-reserve conservation, an alternative model of conservation—referred to here as the Well-Managed Paddock model—has arisen. This has concentrated on searching for win-win solutions to apparent conflicts between conservation and production, and providing best-practice management advice and incentives to encourage farmers and other landholders to implement management practices that provide conservation outcomes. With this model, success is viewed as an increase in the extent to which farmers and local authorities manage their lands for both conservation and production goals.

The Well-Managed Paddock model is achieving much by raising the profile of conservation in rural communities, and improving management of rural lands and landscapes. However, we believe that, just like the National Parks model, it has some significant limitations. Foremost of these is its concentration on management at the expense of formal protection. This partly arises from its target audience—protection of remnants is sometimes seen by local communities as involving loss of control and freedom—and partly from its rejection of the National Parks model, which perhaps emphasises protection (by acquisition) more than management.

This lack of emphasis on protection is problematic because, ecologically, many fragmented ecosystems in Australia are on a ‘one-way street’. The abundance and prevalence of environmental weeds in Australia and the apparent inability of many Australian ecosystems to cope with European-derived agricultural systems mean that it is very easy to destroy a remnant, and very difficult to recreate one. Inappropriate management—too-heavy grazing or soil disturbance—can very quickly reduce the quality of a grassy woodland remnant's understorey, but it appears that even the most appropriate management can only partially reverse this damage except perhaps in the very long term.

For this reason, we believe that the Well-Managed Paddock model alone can, at best, slow the rate at which important remnants are lost from the conservation estate. This is because managers invariably change—they die or sell the property—and there is no guarantee that the new manager will continue the old manager's best practices. Without a means of formally guaranteeing continuance of the management, some sites will continue to be degraded and the rate of loss will almost certainly be greater than the rate at which degraded remnants are restored.

## A middle way- Conservation Management Networks

Both the National Park and the Well-Managed Paddock models have important strengths, but we believe that neither will adequately provide for the long-term conservation of fragmented grasslands and grassy woodlands alone. We need a flexible approach that combines the strengths of both, since both have much to offer, but avoids their weaknesses. We are using the grassy White Box woodlands to develop such a model—the Conservation Management Network—that we believe is applicable to many fragmented ecological communities.

A Conservation Management Network (CMN) is a network of remnants, their managers and other interested parties. A key to the CMN model is a single administrative umbrella that can help coordinate the protection and management of a suite of widely dispersed remnants under different land tenures. Membership of a CMN is voluntary and open to any site that is managed primarily or partly for conservation, and has been given some formal long-term protection by its manager. We envisage that each CMN will be established to protect an ecological community, but some may be established for other conservation outcomes, e.g. to protect scattered habitats of a rare species. The Conservation Management Network model has been formulated using the following principles:

### All remnants are important

With less than 0.05% of grassy White Box woodlands still extant in good condition, every remnant is important. Everything, from isolated trees in paddocks to the small cemetery sites with intact understorey to the larger wooded Travelling Stock Reserves, is important for conserving different elements of biodiversity, protecting landscape functions and heritage values, and in providing resources for land rehabilitation and baseline sites for studies of land degradation. Thus any remnant is considered eligible to join the CMN.

Naturally, however, remnants differ in the context of their importance, from remnants that are locally important, to regionally significant sites that make a significant contribution to landscape function or biodiversity conservation, to nationally significant sites that are critical to the conservation of a nationally threatened ecosystem. Understanding the level of significance along this scale is important in determining levels of support or incentive that may be directed to a site from State or Federal funding bodies.

Conservation of woodland communities is dependent on maintaining the functioning of the landscapes in which they occur. All remnants are seen as contributing to this process and are thus encouraged to join the Network. It is acknowledged, however, that the density and configuration of remnants desirable for maintaining landscape function is unlikely to be achieved within the Network alone, and that other supporting mechanisms such as education and incentives schemes are of great importance.

### The whole is greater than the sum of the parts

In an artificially fragmented ecological community, each remnant generally represents only a small part of the original diversity. Taken together, however, these remnants represent the existing diversity of the community. Sites with different management histories contain different native understorey species and associated small fauna. Small sites may contain a high diversity of herbaceous species, but may lack trees and be too small for many vertebrate animals. Wooded sites are important for their contribution to landscape function and as habitat for tree and log dwelling fauna. Large sites are necessary for the survival of populations of many of the larger birds and mammals. Remnants from different geographical regions contain different animal and plant species, and contribute to conservation of geographic patterns of genetic diversity in more widespread species. Thus, although physically dispersed, the remnants are best treated as a conceptual whole in order to optimise representation of the original diversity of the ecological community.

### Remnants in a network should be permanently protected

Because of the 'one-way street' of remnant degradation, some form of permanent or long-term protection is an essential pre-requisite for membership of the CMN. Protection may be provided using one or more of a number of instruments, including Conservation Agreements, registered Property Management Agreements, and Local Environment Plans. There are no prescriptions built into the CMN as to particular protective instruments, so long as the instrument used provides an adequate level of protection and is not unilaterally revocable. Instruments that focus on negotiated agreement towards conservation goals rather than legislative control and include provision for formulation of management plans rather than simply empty protection are preferred. In some cases, instruments that are less secure might be used as stepping stones towards more permanent protection.

### Management should be coordinated across remnants

It is well recognised ecologically that patch or mosaic management maximises diversity in most ecosystems: some organisms will be favoured and others disadvantaged in any given patch. Mosaic management, such as by patch-burning, is relatively easily attained in broadacre systems, but is very difficult in fragmented ecosystems where the average remnant may be considerably smaller than the ideal management patch. This problem can only be addressed by coordinating management across all remnants to avoid a monoculture of management. In the case of grasslands or grassy woodlands, for instance, overall ecological diversity will probably be maximised if some remnants are consistently managed in one way (with light grazing, for instance) while other remnants are managed differently (by burning at different frequencies or leaving untouched).

### Management of one remnant needs to inform management of others

Ecological management of most Australian ecosystems is in its infancy. In the case of grasslands and grassy woodlands, the effects of fire, grazing and combinations of these on the ecosystem as a whole are only poorly understood. The CMN is designed to make it easier to monitor (either formally or informally) outcomes of management implemented at each site, so that a greater overall understanding of woodland management can be obtained and then spread throughout the Network. The CMN structure will promote adaptive management, both within individual remnants and across the suite of remnants as a whole. We believe that adaptive management is promoted by the ecosystem focus of the Network, with each Network including only those remnants with similar management needs and ecologies rather than a disparate set of remnants chosen for other reasons and lacking any ecological commonality.

### Local involvement in management should be preserved whenever possible

It is usually more appropriate for tenure and day-to-day management of a site to remain with the current tenure-holder than for a site to be acquired and managed by a centralised body. This helps to ensure continuity of historical management practices, which in many cases have led to or at least protected the site's present values: the first danger that many sites face is the discontinuance of historical uses. It also allows production outcomes to continue in some cases, avoids the expensive and potentially threatening process of acquisition by a central agency, and strengthens community awareness of the significance of such sites.

### Membership should raise the status of sites.

There is a danger that small, isolated remnants may become 'lost in the system', or lost through neglect if initial enthusiasm for conservation management wanes. An important attribute of a CMN is its ability to raise the status of sites so that they are viewed as part of a larger whole rather than as isolated fragments with relatively low intrinsic importance. Sites will gain higher status by becoming part of a CMN and this is important for its effect on both managers and funding agencies.

## Structure and function of a Conservation Management Network

We see the CMN as a structure that provides a 'home' for sites and a support network for their managers. The Network itself needs to be housed in an institution or other support structure. We are currently establishing the Grassy Box Woodlands CMN in the New South Wales National Parks and Wildlife Service, as the most appropriate existing agency.

Day-to-day coordination of a CMN requires an ongoing part-time or full-time manager, conceptually equivalent to a Senior Ranger at a National Park. The CMN manager will be responsible for:

- maintaining a schedule or database of all sites within the Network;
- progressing the inclusion of sites, particularly those of national and regional significance;
- liaising with managers of sites, both individually and through Network newsletters and web sites, including provision of general and site-specific management advice;
- visiting sites when appropriate, including regular monitoring of sites of national significance;
- coordinating adaptive management of remnants and monitoring outcomes of management initiatives;
- raising the profile of the Network with other government agencies and the community at large, through media work and presentations;
- providing a central brokerage service for access to funding from external incentives schemes;
- providing a central contact point for government agencies that may have a management interest in Network sites, or that manage development proposals that may affect Network sites;
- reporting to government agencies as part of auditing commitments.

## Links with other programs

The Conservation Management Network structure links strongly with other State and Federal conservation networks and programs. It overlaps directly with the National Reserve System (NRS) Program since a subset of sites protected in a CMN—those of national significance—may be eligible for inclusion in the NRS. We recommend that sites included in a CMN and designated within the context of the CMN as Nationally Significant be considered for eligibility in the NRS. Sites of either national or regional significance are likely to link directly with the native vegetation management and clearing control frameworks implemented in several States.

The grassy White Box woodlands are currently being considered for listing as a threatened ecological community, under both Federal and State Acts. Establishment and maintenance of a CMN will be an important part of the recovery planning process for any scheduled threatened communities.

In addition, the CMN provides a useful structure for formalising outcomes from a range of incentives and education delivery schemes, including local council remnant management and survey programs, and initiatives targeting private landholders.

The benefits of these linkages are exemplified by a site near Boorowa in NSW. A small roadside verge holds an important remnant of grassy White

Box woodland with a rich and diverse native understorey, discovered during a survey in 1993. The site also ranks highly on a complete survey of roadside vegetation being conducted in the Young Shire Council. Negotiations are underway to formally protect the site and include it in the Grassy Box Woodlands Conservation Management Network. Partly as a result of the high profile given to grassy White Box woodlands in the region, an adjacent landholder has contacted a privately-run incentives scheme (the Taking Action Now project funded by the Natural Heritage Trust) requesting assistance to fence off a portion of a paddock adjacent to the roadside remnant. The paddock area contains a partially degraded remnant and, after fencing and exclusion of stock, the landholder intends to try to rehabilitate the site to expand the area of high-quality understorey. The complete site, on several tenures, may one day be included through the CMN in the National Reserve System, and may be a scheduled site in the Grassy White Box Recovery Plan. In this way, many previously independent schemes are working together, with the CMN as a focus, to provide important on-ground conservation outcomes.

## Conclusions

A wide variety of conservation initiatives are necessary if we are to achieve the goal of a sustainable future for grassy woodlands and other fragmented ecosystems. These include: moves towards better farming practices; research on possible win-win solutions to apparent conflicts between production and conservation; establishment of a variety of incentives schemes to encourage private and public conservation; education programs to raise public awareness of conservation issues; vegetation management policies and initiatives from government at all levels; and conventional acquisition programs. Among this gamut of initiatives, we believe that Conservation Management Networks offer an important resource. Conservation Management Networks provides a flexible, adaptable, widely applicable and effective way of capturing and managing conservation values in a challenging landscape.

## References

Prober, S. M. 1996. Conservation of the grassy white box woodlands: rangewide floristic variation and implications for reserve design. *Australian Journal of Botany* 44: 57-77.

Prober, S. M. & Brown, A. H. D. 1994. Conservation of the grassy white box woodlands: Population genetics and fragmentation of *Eucalyptus albens. Conservation Biology* 8: 1003-13.

Prober, S. M., Spindler, L. & Brown, A. H. D. 1998. Conservation of the grassy white box woodlands: Effects of remnant population size on genetic diversity in the allotetraploid herb, *Microseris lanceolata*. *Conservation Biology* 12: 1279-90.

Prober, S. M. & Thiele, K. R. 1995. Conservation of the grassy white box woodlands: Relative contributions of size and disturbance to floristic composition and diversity of remnants. *Australian Journal of Botany* 43: 349-66.

Prober, S. M. & Thiele, K. R. 1993. The ecology and genetics of remnant grassy white box woodlands in relation to their conservation. *The Victorian Naturalist* 110: 30-6.

Thiele, K.R. & Prober, S.M. 1999. Reserve concepts and conceptual reserves: options for the protection of fragmented ecosystems. In: R.J.Hobbs and C.J.Yates (eds) *Temperate Eucalypt Woodlands in Australia: Biology, Conservation, Management and Restoration.* Surrey Beatty & Sons, Sydney.

# The significance and weed management of temperate native grasslands and box grassy woodlands in South Australia

Richard Davies

School of Biological Sciences, Flinders University
GPO Box 2100, Adelaide 5001 SA
Richard.Davies@flinders.edu.au

## Description and distribution

Ask the average person in the street to describe 'Australian bush' and they will talk only of trees and shrubs. Yet biologists and historians know from the descriptions of early European explorers and surveyors that, along with the forests, mallee and heathlands, extensive areas of southern Australia had few or no shrubs or trees at the time of European settlement. For example, in 1849 explorer Charles Sturt encountered '*immense tracts of land… rich in soil and abundant in pasture [with] scarcely a tree upon them… and covered with a profusion of orchidaceous plants.*' We now know that these native grasslands covered approximately 10,000 square kilometres in the Mid-North of South Australia, north of Clare.

Even larger areas from the mouth of the Murray River to the Southern Flinders Ranges had a sparse tree cover, few shrubs, and an understorey of mainly native grasses and forbs (such as daisies, lilies and orchids). Where the trees were mainly Peppermint Box (*Eucalyptus odorata*), Mallee Box (*E. porosa*), Grey Box (*E. microcarpa*), River Box (*E. largiflorens*) or Broad-leaved Box (*E. behriana*), such areas were referred to as 'box grassy woodlands'. Smaller areas of box grassy woodland also occurred on southern Eyre Peninsula and in the Upper South-east. In the latter region, where the heavy clays of the Victorian Wimmera extend into South Australia, the floristically similar Buloke (*Allocasuarina luehmannii*) grassy woodlands were once locally common. Figure 1 shows the former distribution of these poorly conserved temperate native grasslands and box grassy woodlands in South Australia, based on Specht (1972).

## Habitat value

Temperate native grasslands and box grassy woodlands provide habitat for a wide range of plant and animal species that do not occur in the more common and better conserved plant communities. Some such plant species were previously very widespread, but are not yet listed as rare or threatened since they are still moderately common on roadsides or in small remnants of vegetation, although not adequately conserved in conservation reserves and Heritage Agreement areas. The gradual, incremental degradation of such areas continues to destroy populations and, over several decades, increasing numbers will appear on threatened species lists unless proactive programs are implemented to protect such habitats.

A similar decline is occurring with bird species that rely on moderately intact savannah understoreys. Robinson (1993) describes 41 species of land birds as threatened and at least a further 57 land bird species as having disappeared from, or being in decline in, regions of southern Australia. He further states—'*Of those species declining, 80% occur in grassy woodland or box-ironbark habitats, the majority of them forage at least partly on the ground (58%) and 30% nest on or close to the ground*.'

A number of threatened plant species are totally or largely confined to temperate grasslands or box grassy woodland habitats. For example, the only known population of the nationally endangered

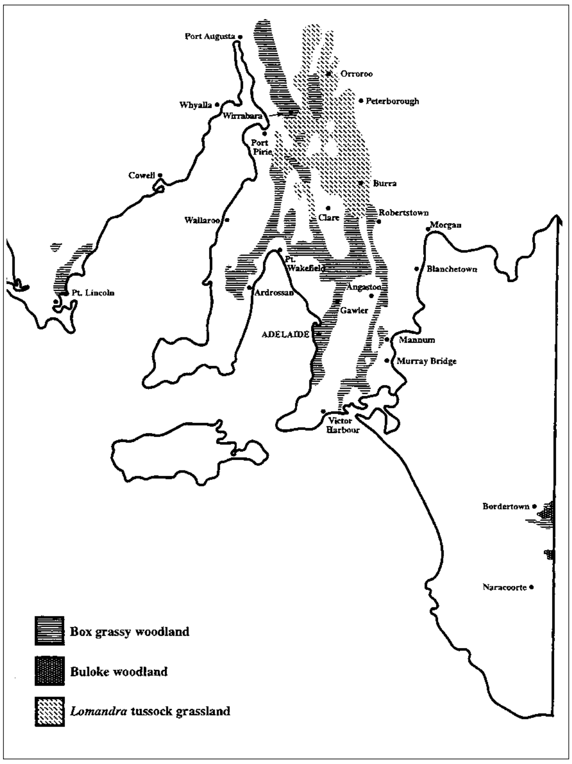



Figure 1. Previous distribution of box grassy woodlands, buloke woodlands and *Lomandra* tussock grasslands in South Australia (adapted from Specht 1972)

perennial Blown Grass (*Agrostis limitanea*) survives in only 0.3 ha of grassy wetland at the edge of a road in the Mid-North of South Australia where it is threatened by weed invasion (Ellis 1994; Davies 1995). Similarly, the last stronghold in SA for the nationally endangered Small Scurf-pea (*Cullen parvum*) is grasslands in the Mid-North, where it is not conserved and is under threat from road maintenance activities, weed invasion and grazing (Davies 1986, 1992, 1995, 1997; Bates 1988). The as-yet-undescribed nationally endangered orchid ‘Pterostylis aff. despectans (Mt Bryan)’ is only known from grazed *Eucalyptus odorata* grassy woodland north of Mt Brian (Davies 1997).

A number of threatened fauna species are also confined to temperate grassy ecosystems. Since its rediscovery in 1992, the nationally endangered Pygmy Bluetongue lizard (*Tiliqua adelaidensis*) has only been found in native grasslands in the vicinity of Burra in the Mid-North. The greatest potential threat to these populations is the ploughing of native grasslands, the species apparently being dependent on spider holes (Cogger *et al.* 1993) that are destroyed by cultivation.

The White-veined Skipper butterfly (*Anisynta albovenata albovenata*), which occurs in Mid-North grasslands, is considered nationally endangered (Soon Poh Tay 1992). The species is endemic to South Australia and has been relocated in vegetation bordering a disused railway line in the Mid-North. Recent soil disturbance during the removal of railway lines has resulted in invasion by exotic grasses which could threaten the host plant of this butterfly, Fibrous Spear-grass (*Stipa semibarbata*) (Fisher 1992).

The nationally vulnerable bird Plains-wanderer (*Pedionomus torquatus*) is also largely dependent on at least partially-native grasslands. This bird species requires sparse grasslands with about 50% bare ground, widely spaced plants up to 10 cm high, and remaining standing vegetation less than 5 cm in height. Cultivation, improvement, and overgrazing of native pastures are major reasons for the disappearance of the species (Garnett 1992).

## Conservation status

Although previously widespread, temperate native grasslands and grassy woodlands are the most poorly conserved and most threatened plant communities in South Australia. As well as having been almost all cleared for agriculture or severely degraded by prolonged heavy grazing, the relatively fertile soil on which they occurred made them highly vulnerable to weed invasion. Of the less than 1% of temperate native grassland and less than 5% of grassy woodland remaining in South Australia, the majority is heavily weed invaded.

A 1982 study into the conservation status of South Australian plant communities (Davies 1982) found that Iron Grass (*Lomandra effusa* ± *Lomandra multiflora ssp. dura*) grasslands, Wallaby Grass and Kangaroo Grass (*Austrodanthonia* spp. – *Themeda triandra*) grasslands, Buloke (*Allocasuarina luehmannii*) low woodlands, and Broad-leaved Box – White Mallee – Peppermint Box (*Eucalyptus behriana - E. phenax - E. odorata*) open-scrub were all ‘very rare and endangered in South Australia’. All were found to be either poorly conserved or not conserved. Similarly, Peppermint Box (*E. odorata*) low woodland was described as poorly conserved with most remaining examples being small and/or degraded and/or atypical. Grey Box (*E. microcarpa*) woodlands and Mallee Box (*E. porosa*) woodlands were both described as poorly conserved, but with larger examples still remaining in South Australia.

A similar study (Neagle 1995), undertaken a decade later in 1992, found the situation little changed for several of these communities. *Lomandra effusa* ± *Lomandra multiflora ssp. dura* tussock grassland, *Austrodanthonia* spp.– *Themeda triandra* tussock grassland, *Eucalyptus odorata* woodland, *Allocasuarina luehmannii* woodland, and *Eucalyptus behriana – E. phenax - E. odorata* open-scrub were found to be still poorly conserved or not conserved.

Until recently, the only conserved example of species-rich temperate grasslands was confined to five hectares of Mount Brown Conservation Park (Davies 1997). However, within the last year, 400 hectares of native species-rich grassland near Mount Cone (c. 20 km), north of Burra, has been acquired by the State government as a grassland reserve. This reserve contains significant populations of two nationally threatened plant species: Small Scurf-pea (*Cullen parvum*) and Trailing Hop-bush (*Dodonaea procumbens*).

While Mount Brown Conservation Park and extensions to Mount Remarkable National Park both contain 30 hectares of *E. odorata* woodland, both areas are potentially under threat from vehicle-based camping activities. A further 100 to 150 ha of this grassy woodland plant community on privately owned land have been protected under Heritage Agreements, a State government initiated scheme in which land owners legally agree not to clear or graze the designated areas in perpetuity. However, these areas are generally small and often weed invaded.

On a brighter note, subsequent to Neagle (1995), 700 ha and 100 ha of *E. microcarpa* woodland have been conserved in Mount Brown Conservation Park and additions to Mount Remarkable National Park respectively (Davies 1997). While *E. porosa* woodland is still poorly conserved, Neagle (1995) upgraded *E. porosa* low woodland to moderately conserved due to the protection in recent years of a number of areas under Heritage Agreement.

## Threats

Temperate grasslands and grassy woodlands occur in areas of South Australia where rainfall is relatively reliable. They also only occur on relatively heavy soils and are largely confined to plains and rolling hills. Such factors made such areas prime targets for agricultural development early on following European settlement (Hyde 1996). Thus these communities have been extensively cleared for agriculture throughout their range.

In South Australia, the *Native Vegetation Act 1991* now regulates the clearance of native vegetation. Permission to clear threatened plant communities is generally not granted, except where the native understorey has been totally replaced by exotic species. While this Act also covers native grasslands and grassy woodlands, exemptions under the Act mean that these plant communities continue to be cleared or heavily grazed. Firstly, mining activities are not covered by the Act. This has enabled quarrying to be recently extended into an area of *E. odorata* woodland of State significance near Truro.

The Act also exempts the clearance of native vegetation for the erection of buildings, firebreaks, fencelines and driveways. Thus, the clearance of *E. porosa* and *E. microcarpa* woodlands still continues in the Adelaide Hills and, due to small block sizes, continues to have a major impact on surviving examples of these communities.

Illegal clearance is also a threat. Native grasslands are particularly under threat due to the general public perception that they are not native vegetation. One of the most diverse and extensive areas of native grasslands near Burra was recently almost ploughed due to the owners not realising it was covered by the Native Vegetation Act.

While the Act considers domestic stock grazing to be a form of clearance, it exempts the continuation of grazing as long as it is consistent with the manner and rate of grazing that the vegetation has been subject to over the previous ten years. If heavy and prolonged grazing occurs, palatable native forbs such as legumes, lilies, daisies and orchids are the first species to disappear, not the grasses. Consequently, the majority of rare and threatened plants in grasslands and grassy woodlands are palatable forbs, not grasses.

In many local regions, grassy woodlands are confined to roadside vegetation. Such areas are threatened by road construction and maintenance activities. The import of weed propagules has resulted in such areas being heavily weed invaded.

Due to a lack of awareness of the importance of grassy woodlands, these areas are often targeted for roadside rest areas, passing lanes and gravel dumps instead of areas with more shrubby understoreys. Since grassy woodlands are often more weedy than plant communities occurring on less fertile soils, they are frequently damaged by heavy-handed weed control, such as bulldozing and herbicide spraying.

A new threat has arisen in recent years with the greatly heightened interest in tree planting. Frequently, areas chosen for such activities are road reserves and other council reserves. Due to the relative absence of trees, areas containing grasslands and grassy woodlands are frequently targeted for tree planting projects. And, in several instances, extensive damage has been done to the ground layer during ripping and herbicide spraying.

## Weed invasion

Weed invasion poses a major threat to most surviving examples of temperate native grasslands and grassy woodlands. Many exotic species are better adapted than indigenous understorey species to growing in the relatively fertile soils associated with these communities. This is particularly the case where understoreys are still being grazed or were previously grazed. Undisturbed soil contains a lichen or moss crust, and native seeds are generally better adapted to penetrating these hard crusts than are the seeds of many exotic species. Many exotic weed species, on the other hand, thrive well on the disturbed soils created by stock trampling, or are better adapted to survive stock grazing.

This problem of weed invasion is further exacerbated by the small size of many examples of these communities and their proximity to agricultural lands. The smaller the block size, the greater the block boundary to area ratio. It is through these boundaries that weeds invade from adjacent agricultural lands.

Many of these environmental weeds are not weeds on agricultural lands and thus have not received much attention from government agencies or in the scientific literature. On the contrary, some of the more highly invasive weeds, such as medics and some exotic grasses, are still being promoted by government agencies to 'improve' pastures or to stabilise degraded areas. This has included the past seeding of pastures from the air, with native pastures and exotic pastures alike being targeted in some regions.

## Weed management

Bushland managers are increasingly adopting an ecological approach, rather than a single species approach, in their bushland regeneration strategies. This was the approach I used during a three year experimental study into weed control in natural bushland (Davies 1997).

Data collected from over a decade of vegetation surveying in South Australia was analysed to determine which native species most commonly occur in surviving grassy ecosystems, and which are the most widespread and highly competitive weeds. It was found that 72% of highly invasive weed species of temperate native grasslands and grassy woodlands in South Australia are annuals, while 90% of common indigenous species are perennials. In degraded grassy ecosystems the absence of native annuals is particularly prevalent, and, in such areas, management activities that favour perennials over annuals have the potential to reduce weed cover.

The study also found that a diversity of perennial forbs occur in native grasslands and grassy woodlands, despite the grassy appearances. This must be taken into account whenever treatments such as broadleaf herbicides are considered.

Part of the study involved determining when common weeds and native species of native grassy ecosystems actively grow and flower, to determine the timing and frequency of treatments most likely to deplete weeds while maintaining native species diversity. It was found that, while most annual weeds and weed bulbs grow actively during winter to mid-spring and die back at the end of spring, many of the hardier native perennials continue to actively grow into late spring, as well as after good summer rains and immediately following opening rains in autumn. However, a significant number of native bulbs and annuals grow at the same time as the annual weeds, and a group of perennial grass and broadleaf weeds grow at the same time as most native grasses.

The study concluded that weed management strategies that favour summer growing over winter growing species will disadvantage most annual weeds while benefiting many native perennials, in particular grasses. However, it warns that such management also favours some highly invasive perennial weeds, while disadvantaging many native annuals and native geophytes (including many orchids) if present.

Thus there is a need for regenerators of native grasslands and grassy woodlands to know all the native species and highly invasive weed species occurring at a site before they burn, spray or slash. Not only do they need to know where sensitive natives and serious weeds occur, they must also know which of these species are actively growing when, to develop effective weed management strategies.

Methods trialed experimentally in the study included the use of the grass specific herbicide fluazifop-butyl (tradename 'Fusilade'). This was found to have great potential in the control of exotic annual grasses in native grasslands and grassy woodlands. Most annual exotic grasses, with the exception of Silver Grass (*Vulpia* spp.) and Winter Grass (*Poa annua*), are killed at the 3-5 leaf stage by spray application at the rate of 0.5 L/ha, while seed production was found to be disrupted at early tillering by applications of 1.0 L/ha. In comparison, all of the 15 native perennial grass species on which the higher rate was trialed were found to be resistant, as were all 43 native non-grass species tested. Field trials in *E. odorata* grassy woodland found that spraying at 1.0 L/ha did not significantly reduce the density of any native perennial species, and actually resulted in a significant increase for one such species, native Oxalis (*Oxalis perennans*), apparently as a result of decreased weed competition.

In contrast, with the exception of Umbrella Grass (*Enteropogon acicularis*), all 35 native species trialed in *ex situ* plots were found to be highly susceptible to glyphosate (tradename 'Roundup') at the commonly used concentration of 1:100 when spot spraying (until runoff) on 18 month old individuals. Thus the broadacre spraying of glyphosate to kill woody weed seedlings in native grasslands and box grassy woodlands is not recommended. All perennial weeds trialed were found to be similarly susceptible, indicating the suitability of use of this herbicide in these communities when carefully spot sprayed or applied using a wick-wiper or the cut-and-swab technique.

Carefully timed slashing was also found to have the potential to control exotic bulbs, exotic annual grasses and some exotic broadleaf annuals, while favouring some native grasses. However, it can also favour summer growing perennial weeds. Late autumn and early spring slashing in a *Eucalyptus porosa* grassy woodland was found to significantly reduce cover of the exotic geophyte Guildford Grass (*Romulea rosea*) and to increase density of the native Bulbous Speargrass (*Stipa gibbosa*). Carefully timed slashing was also found to significantly reduce the cover of the exotic Woolly Star-thistle (*Carthamnus lanatus*) and the exotic grasses False Brome (*Brachypodium distachyon*) and Wild Oats (*Avena barbata*) in *E. odorata* grassy woodland for the remainder of the growth season. In contrast, the perennial exotic forb Ribwort (*Plantago lanceolata*) increased in density with slashing. Significantly, only three of 45 native grassland/grassy woodland species subject to trial slashing in late winter were unable to regenerate by reshooting at the base.

A major component of the report resulting from this study (Davies 1997) was the literature review. This included a detailed analysis of other research that has been done relevant to the use of fire, grazing, and the herbicides atrazine (tradename 'Atrazine') and metsulfuron-methyl (tradenames 'Brush-off' and 'Ally') to manage weeds in native grasslands and grassy woodlands. Ways of preventing further weed invasion were also discussed along with minimal impact methods such as handpulling, digging and cutting and swabbing.

## References

Bates, R. 1988. A note on *Psoralea parva* F. Muell. in South Australia. *South Australian Naturalist* 62: 57.

Briggs, J.D. & Leigh, J.H. 1996. *Rare or Threatened Australian Plants* (2nd edn). CSIRO Publishing, Canberra.

Cogger, H.G., Cameron, E.E., Sadlier, R.A. & Eggler, P. 1993. *The Action Plan for Australian Reptiles.* Australian Nature Conservation Agency, Canberra.

Davies, R.J.-P. 1982. *The Conservation of Major Plant Associations in South Australia.* Conservation Council of South Australia Inc., Adelaide.

Davies, R.J.-P. 1983. *Surviving Examples of South Australia's Most Threatened Plant Associations*, Conservation Council of South Australia Inc., Adelaide.

Davies, R.J.-P. 1986. *Threatened Plant Species of the Mount Lofty Ranges and Kangaroo Island Regions of South Australia*. Conservation Council of South Australia Inc., Adelaide.

Davies, R.J.-P. 1992. *Threatened Plant Species of the Murray Mallee, Mount Lofty Ranges and Kangaroo Island Regions of South Australia*. Conservation Council of South Australia Inc., Adelaide.

Davies, R.J.-P. 1995. *Threatened Plant Species Management in National Parks and Wildlife Act Reserves in South Australia*. Black Hill Flora Centre, Adelaide.

Davies, R. J.-P. 1997. *Weed Management in Temperate Native Grasslands and Box Grassy Woodlands in South Australia.* Black Hill Flora Centre, Adelaide.

Davies, R. J.-P. 1999. Description, Distribution, Conservation Status and Weed Management of Box and Buloke Grassy Woodlands in South Australia. In: R.J.Hobbs and C.J.Yates (eds) *Temperate Eucalypt Woodlands in Australia: Biology, Conservation, Management and Restoration*. Pp.167-89. Surrey Beaty and Sons, Chipping Norton.

Ellis, M. 1994. *Agrostis limitanea*?: The tenuous existence of an endangered species. *The Networker*: South Australia's Threatened Species Network Newsletter, July 1994.

Fisher, R.H. 1992. Some endangered or threatened species of butterflies (Lepidoptera: Hesperioidea) and their habitats in the Mid North of South Australia. South Australian Museum, Adelaide. (unpub.)

Garnett, S. 1992. *The Action Plan for Australian Birds*. Australian National Parks and Wildlife Service, Canberra.

Hyde M.K. 1996. *Eucalyptus odorata* woodland in South Australia. Report to Australian Heritage Commission, Canberra. (unpub.)

Neagle, N. 1995. *An Update of the Conservation of the Major Plant Associations of South Australia*. Native Vegetation Conservation Section, Department of Environment and Natural Resources, Adelaide.

Robinson, L. 1993. Vale Toolern Vale: the loss of our woodland birds. *Wingspan* 9: 1.

Specht, R.L. 1972. *The Vegetation of South Australia*. Government Printer, Adelaide.

Sturt, C. 1849. Journal of the Central Australian Expedition 1844-5 and an account of the sea coast and interiors of South Australia. *Facsimile of Charles Sturt's narrative of an Expedition into Central Australia* 2:145-286.

Tay, Soon Poh 1992. *Threatened Species and Habitats in South Australia*. South Australian Advisory Committee on Threatened Species, Adelaide.

# Management of the Pygmy Bluetongue lizard (*Tiliqua adelaidensis*) on private grazing properties, Mid-North SA

Sylvia Clarke

Pygmy Bluetongue Recovery Program
South Australian Museum, North Terrace, Adelaide, SA 5000
sylviac@senet.com.au

Twelve populations of the peculiar Pygmy Bluetongue lizard (*Tiliqua adelaidensis*) survive in grazed native grassland in the mid-north of South Australia, a remnant of their former distribution that extended as far south as the Adelaide plains. The present populations are geographically isolated, each being surrounded by cultivated land, and within each site the lizards exhibit a clumped distribution ranging from 15 to 200 animals per hectare. Pygmy Bluetongues lead a largely sedentary life, in burrows dug by wolf and trapdoor spiders. Active by day, they feed on insects and some plant material. Maximum length is about 18 cm and, from three years of age, females can have up to 4 live young every year. Their main predators are raptors and elapid snakes.

Pygmy Bluetongues only survive in native grassland that has never been cultivated, but the relationship is not simple, as the largest populations are not in the highest quality grasslands. Other factors, still uncertain, must also be important in determining their abundance and distribution. All known populations are on private land and the monitored populations appear stable. The survival of the species will largely depend on landholders' willingness to ensure that potentially disruptive land use practices (e.g. salt bush planting, spraying grasshoppers) do not impact areas where Pygmy Bluetongues occur. Over the next year it is hoped that management agreements can be negotiated with some landholders, in recognition of the importance of their role in the survival of these distinctive lizards.

*Keywords: grassland fauna, Pygmy Bluetongue lizards, grassland management*

## Introduction

The Pygmy Bluetongue lizard is an endangered reptile presently restricted to isolated patches of native grassland in the Mid-North of South Australia (Cogger *et al.* 1993; Hutchinson *et al*. 1994). Since the beginning of the Pygmy Bluetongue Lizard Research Plan in 1992, much effort has been spent uncovering the biology and general ecology of this peculiar animal. The focus has recently shifted from research to recovery, to find the best way to manage the populations and ensure their survival into the future. The future of the lizard is directly connected with that of the native grasslands, which in turn is reliant on the management practices of the Mid-North graziers.

## The lizard

Pygmy Bluetongues belong to the same genus as other bluetongues and sleepy lizards (*Tiliqua*), but despite the name do not share their blue tongue. They are much smaller than the other bluetongues, growing to a total length of no more than 18cm, with females slightly larger than males. Their colour varies from grey-brown to orange-brown and from highly spotted to plain. Different sub-populations exhibit different frequencies of body pattern types; the most northern population has only spotted lizards while the more southern populations contain both plain and spotted individuals. The lizards feed on grasshoppers, caterpillars, introduced snails and a small amount of plant matter (Ehmann 1982; Hutchinson *et al.* 1994).

Pygmy Bluetongues of both sexes become sexually mature at about 20 months and from then can mate each spring. In late summer females give birth to 1 to 4 young, larger females tending to have larger litters. The young initially share the mother's burrow, but begin to disperse to find holes of their own within a week of birth. Juvenile mortality is estimated to be greater than 80% over the first two years of life (Milne 1999). Natural predators include brown snakes and birds of prey.

## The habitat

Pygmy Bluetongues are only found in native grassland in the Mid-North of South Australia. Population density varies greatly between sites, from up to 200 lizards per hectare to as few as 15. Pygmy Bluetongues are found in thin (10-20 mm diameter), vertical burrows in intertussock spaces (Milne 1999). In the warmer months the lizards spend the majority of their time basking at the entrance to their burrow and ambushing passing insects. At the slightest disturbance they duck back into the safety of the burrow. For this reason they are rarely seen. Their cryptic nature has necessitated the use of an optic-fibrescope for monitoring, allowing observation inside the burrows. In late summer the number of young with each mother can also be assessed using the optic-fibrescope. When lizards need to be caught for measuring or individual identification, fishing line with a grasshopper or mealworm tied to the end is used to lure the occupant from the burrow.

The burrows are made by spiders. Trapdoor spiders make the widest and longest burrows most preferred by the lizards (diameter of greater than 16mm and depth greater than 200mm). Wolf spiders make smaller burrows that are often used by the juveniles (Milne 1999). The lizard's ecology is obviously closely tied in with that of the spiders, but unfortunately there is a great lack of knowledge about these spiders.

Artificial burrows made from hollow wooden dowel have been added at some of the sites and are readily used by the lizards, particularly juveniles. This may be one way to increase population numbers. The artificial holes are also useful for monitoring. As they are straight, unlike the spider burrows, they can be checked for lizard occupancy with a torch rather than the optic-fibrescope. This allows them to be easily checked by the landholders or members of a Friends Group.

## Sites

Pygmy Bluetongues were previously found as far south as Adelaide, but are now restricted to 12 sites on privately owned grazing properties within a 70 km stretch of the North Mt Lofty Ranges, in the Mid-North of South Australia. In the 1800s specimens were collected at Sevenhill (close to Clare), Gawler and at Dry Creek just north of Adelaide. In the 1940s they were found at Burra and in 1959 two were spotted at Marion, a suburb of Adelaide (Ehmann 1982). However, in the last decade they have only been found between Burra and Peterborough in the Mid-North.

## Management issues

Each population is geographically isolated from the next by cultivated land. Most of the native grassland that remains is on hill slopes, the vast majority of the flatter areas having been ploughed. Cultivation destroys the burrows and any lizards occupying them, as well as permanently altering the vegetation and soil characteristics.

Pygmy Bluetongues are known to move between burrows, but tend to remain within a relatively small area. Most females and a proportion of males were observed to move less than 20 metres from their place of first capture during a 3-year period (Milne 1999). It is uncertain just how far they can travel, but moving long distances without shelter would greatly increase their chance of predation. It is likely, therefore, that large areas of unsuitable habitat surrounding the populations would prevent gene flow.

All known populations coexist with sheep and have been doing so since the first sheep came to the Mid-North. The best management option at present appears to be for the graziers to continue with their present management regime. However, to guarantee the species' long term survival, and to achieve a downgrading from endangered to vulnerable, management agreements will need to be negotiated with the landholders. To do this, a little more needs to be known about how different management options may affect the lizards. Two issues that are most important at present are grazing regimes and pesticide spraying.

If sheep are removed from the grasslands the weeds and grasses may flourish and close the spaces between the native grass tussocks leaving the lizards nowhere to bask. The lizards appear to share the need of the Plains-wanderer and Sun Moths for open grassland habitat. Alternatively, overgrazing may remove too much vegetation and depress the insect populations, depriving the lizards of their main food source. It would also leave the lizards more exposed to predation. It seems likely that a conservative level of grazing (perhaps rotational grazing) may be the best option.

Another issue is the spraying of pesticides. Last spring (1998) the Mid-North experienced a grasshopper plague, which was controlled with the spraying of an organophosphate pesticide, Fenitrothion. This pesticide is known to kill birds (Pearce 1971) and aquatic invertebrates (Dennis Hopkins, Plague Locust Commission pers. comm.), but has a short half-life (Symmons 1985). Patch spraying was undertaken and only one Pygmy Bluetongue site appears to have been sprayed. The lizards in the sprayed habitat appeared unaffected a few days after spraying. It is probable that the lizards were disturbed by the spraying and remained deep in their burrows. However, grasshoppers are a major food source for the lizards. The lizards are to be checked again this spring to see if there have been any longer-term effects. Body condition indices have been calculated for healthy lizards so the condition of the lizards post-spaying can be compared to that of healthy ones.

Other projects of the Recovery Program include captive breeding trials at the Adelaide Zoo, as yet without success, and establishing the levels of genetic variation within and between the isolated sub-populations. Early genetic studies have shown the most northern population to be genetically distinct from the southern ones, correlating with the different colour pattern frequency (Rogers 1998). The genetic difference suggests the population should be treated as a separate management unit.

The project is also beginning to delve into translocation biology. Information is being gathered on why the lizards are found in some patches of native grassland and not others, what is the optimum habitat structure and what is limiting population numbers at the various sites. It is hoped that this will be used to establish a new population in a more secure area, possibly Mt Cone Conservation Park.

The local Burra Community School owns native grassland in Burra and assists the project with longer-term experimental studies of the effects of grazing exclusion, pasture improvement and fire, along with trialing different types of artificial burrow. A Friends Group is also proposed and it is hoped that these efforts to increase the community's involvement in the project will allow the people of the Mid-North to carry on the conservation of the Pygmy Bluetongue. At present, management agreements are being negotiated with two local graziers. With luck, this will be the beginning of a long and successful partnership, satisfying the needs of the lizards and the local landholders. For, along with the native grasslands and the spiders, the Pygmy Bluetongues' lives are also dependent on the Mid-North graziers.

## References

Cogger, H., Cameron, E., Sadlier, R. & Eggler, P. 1993. *The Action Plan for Australian Reptiles.* Australian Nature Conservation Agency, Canberra.

Ehmann, H. 1982. The natural history and conservation of the Adelaide Pygmy Bluetongue lizard. *Herpetofauna* 14: 61-76.

Hutchinson, M.N., Milne, T. & Croft, T. 1994. Redescription and ecological notes on the Pygmy Bluetongue *Tiliqua adelaidensis* (Peters 1862). *Transactions of the Royal Society of South Australia* 118 (4): 217-26.

Milne, T. 1999. Conservation and ecology of the endangered Pygmy Bluetongue lizard *Tiliqua adelaidensis*. PhD thesis, Flinders University of South Australia, Adelaide.

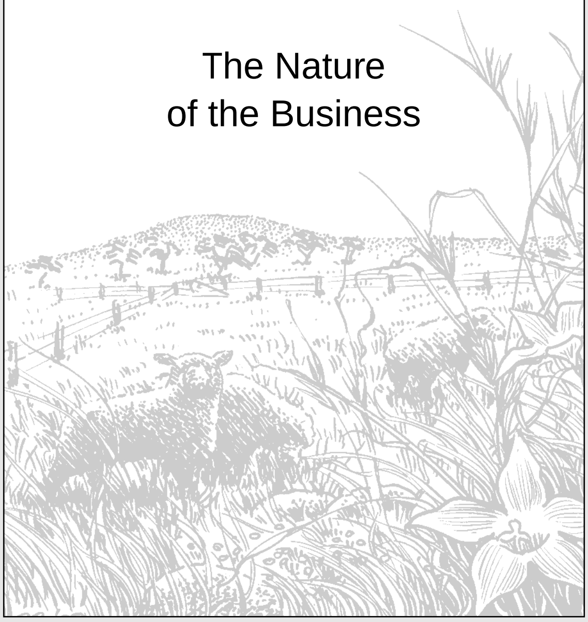
Pearce, P.A. 1971. Side effects of forest spraying in New Brunswick. In: J.B. Trefethen (ed.) *Transactions of the Thirty-Sixth North American Wildlife and Natural Resources Conference*, pp. 163-170. Wildlife Management Institute, Washington D.C.

Rogers, K. 1998. Populations and conservation genetics of the Pygmy Bluetongue lizard, *Tiliqua adelaidensis*. Honours thesis, Department of Genetics, University of Adelaide.

Symmons, P. 1985. Locusts, the plague of '84. *Australian Natural History* 21 (8): 327-330.

# Session 4

## The Nature of the Business



# Grazing management of native pastures in hill country

Simon Ellis

Ellis Farm Consultancy
Box 119, Verdun SA 5245
simellis@senet.com.au

Native grasses are more productive and persistent under rotational grazing than continuous grazing. Most hill country in SA, however, is continuously grazed. Graziers can immediately improve the productivity and persistence of their native grass pastures by, in simplest form, running twice the number of animals for half the time rather than set stocking.

To fully implement rotational grazing, additional subdivisional fencing is generally required. With the current low profitability of sheep and beef cattle, graziers are unlikely to be able to recoup investment for subdivision.

Graziers have tended to maintain stock numbers in spite of reduced fertiliser application. This has effectively increased stocking rates, putting even more pressure on native grasses. Native grass pastures should either be fertilised annually at maintenance, or the stocking rate reduced to offset the lowered pasture production.

Without an increase in commodity prices, there is no easy solution to these issues. Hill country pastures are particularly at risk in the long-term due to the high cost of management and fencing and their environmental sensitivity.

In spite of the remarkable persistence of native grasses, they are declining in most of the state's hill country. Once they are lost, they are gone forever – current technology cannot commercially re-establish them. They are the most economic pasture base in hill pastures and profitable grazing systems need them to persist and produce at their best.

# The farm business and natural resource management

Jim Crosthwaite

Institute of Land and Food Resources
University of Melbourne, Parkville VIC 3052
j.crosthwaite@landfood.unimelb.edu.au.

Considering native grassy vegetation as just one of many resources that are utilised within the farm business opens up new prospects for achieving its conservation.

Farm management economics can help evaluate alternative survival strategies for the farm business, and how native grassy vegetation might fit within those strategies. After an assessment of all the resources available to the farm business, investment opportunities can then be identified and evaluated for their effects on the profitability and cash flow of the whole farm business and on other goals of the owners.

It will be shown through case studies that the next best investment on the farm may sometimes be on native grassy vegetation, and at other times it will not be. It will also be shown that if a more profitable business strategy than the present one can be identified and successfully implemented, then any costs associated with conservation become more affordable. The message to land owners, their advisors and extension officers is to creatively think about different business strategies for the whole farm, and what place native grassy vegetation might have in them.

The message to conservation policy makers is to adopt approaches which assist owners to set new directions for the farm business or which change production systems across the whole farm. Treating 'whole farm' instruments as complementary to mechanisms like covenants, fencing grants and rate rebates is more likely to increase long-term chances of success and minimise public costs.

*Keywords: farm business, strategy, conservation*

## The whole farm approach and native grassy vegetation

Farm leaders often say that farms need to be profitable before there will be more conservation. Meanwhile, public initiatives in conservation and land management tend to focus naturally on physical areas that are of public interest, such as grasslands, rather than on other entities such as farms or grazing systems. A link between the private and public interest can be made by using farm management economics. The whole farm orientation of this approach makes it a suitable method for examining the use of any area in a farm business context (Boehlje & Eidman 1984; Makeham & Malcolm 1993).

The farm management economics perspective is valuable because it can accommodate differences between farms in terms of goals of the owners, the available resources, and how those resources are combined in the various farm activities. In this perspective, all the significant influences on a farm business need to be considered if the place of native grassy vegetation within the farm system is to be understood. It is argued here that treating native grassy vegetation as just one of many resources that are utilised within the farm business opens up new prospects for achieving its conservation.

The economic value of native grassy vegetation to the farm business is determined by its expected contribution to net profit for the farm business. This contribution is relative. It depends on other possible uses of all the resources under the owners' control, including the land occupied by the native grassy vegetation. Expectations about how the contribution of different resources might change in the future are also important.

The starting point for an assessment of a farm business must be its current profitability and cash flow. This is followed by an assessment of the available resources, including the characteristics of each pasture type and its contribution to feed supply. Different options for utilising the native grassy vegetation area and other farm resources can then be examined. The standard budgets of farm management economic analysis (Makeham & Malcolm 1993) are used for this purpose. Economic and financial criteria for evaluating the options include extra profit/loss, comparative return on marginal capital invested, capacity to finance the change, and riskiness. The options can then be evaluated for their effects on conservation values and long-term sustainability.

Conservation management options for native grassy vegetation can be evaluated in a similar way. These options may be directed at improving the long-term productivity of the land from which the owner will ultimately benefit, or may aim to maintain conservation values and minimise off-site effects of agricultural activity from which the public or others primarily benefit. Examples include temporarily de-stocking or resting the pasture, retiring land from production, and subdivision to allow better grazing control. The aim is to see how these options would fit into a changed farm business operation—specifically, whether significant loss of income will result.

## The case studies

Results from eight case studies provide insight into the place of natural resources within farm businesses[1]. Four case studies have been undertaken on the natural grassland areas of the Riverine Plain in Victoria and NSW (Crosthwaite & Malcolm 1999) and four on the hills and tablelands of those States (Crosthwaite & Malcolm 1998). A criteria for selecting these case study farms was that native grasslands or pastures be important in the farming system. All the properties on the Riverine Plain and the one in south-western Victoria have native grasslands with conservation characteristics recognised as important by governments (Department of Environment 1996; Department of Natural Resources and Environment 1997). By contrast, the hill properties have native pastures valued for their place in sustainable farming systems, specifically for providing grazing opportunities while minimising erosion, salinity, and acidity problems. These native pastures, usually with few native species other than grasses, are generally found on more difficult terrain or soils; they complement introduced pastures on the farm.

Current management of grasslands varies, although there are some common elements. None of the farms studied employ a regular rotational grazing system. Only one consistently rests native grassland in spring. Others may rest paddocks in particular years. Several are increasing the amount of resting. Long-term stocking rates may be higher than desirable from a conservation management viewpoint on several properties. The native grassland occupies between 40 and 100% of the grazing area on the properties (Table 1).

Table 1. Characteristics of the case study farms

| | Case farm | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Plains | | | | Hills | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Size - ha | 4,791 | 8,000 | 2,430 | 852 | 361 | 907 | 1,215 | |
| Area of farm in native pasture - % | 100 | 94 | 30 | 87 | 66 | 75 | 63 | 75 |
| Crop & fallow area - ha. | | 500 | 1,619 | 50 | | | | |
| DSEs carried | 5,860 | 8,619 | 7,150 | 2,092 | 6,658 | 3,300 | 5,616 | 8,003 |
| Ewes - no. | 2,500 | 3,500 | 2,700 | 700 | 1,725 | - | 1,250 | 2,500 |
| Wethers - no. | 0 | 0 | 1,700 | 400 | 1,000 | - | 900 | 1,200 |
| Fat lambs (bought in) - no. | | | 1,000 | | | | | |
| 2 yo fine wool - no. | | | | | | | 700 | |
| Beef cows - no. | | 80 | | | 100 | 60 | 12 | 60 |
| Dairy cows - no. | | | | | | 100 | | |

1 A ninth case study farm on the basalt plains of southwestern Victoria has also been undertaken (Crosthwaite and MacLeod, in press).

Self-replacing flocks of merino sheep are run on all but one property. They also carry some wethers, and several produce cross-bred lambs. One farm runs a dairy herd, and several carry beef cattle. Stocking rates were found to be lower on the native grassland than on introduced pasture. The contribution of native pasture to animal feed supply ranges is above 30 per cent in all cases. The seasonal variation is important, with native pasture contributing relatively more when green feed is short in summer and autumn.

There is considerable short-term financial pressure on several of the case farms (Table 2). Return to capital is not generally high. Many carry sizeable debt. Net cash flow is often negative or low. Farm goals vary and are influenced by the age of the operators, level of off-farm income, number and age of dependents, and expectations about the future of the farm. Most need to increase income in the long-term if the farms are to remain viable units.

The outlook for the properties on the Riverine Plain is mixed. Case farm 1 is a grazing property on which income needs to increase. The owners expect to achieve this by expanding the area of saltbush planted, which will particularly increase income in poor years. This approach is arguably compatible with maintaining conservation values.

On case farm 2, sheep and cattle are grazed and rice is also grown. Net farm income is currently better than on case farm 1, but maintaining it in future is considerably more uncertain as the farm has an insecure water entitlement and faces possible pasture decline due to expansion of unpalatable Dillon Bush (*Nitraria billardierei*). The owner's options are to do nothing, stock more lightly, or plant Old Man Saltbush (*Atriplex nummularia*). Stocking more lightly will cause cash flow to drop unacceptably. While saltbush plantations are likely to be profitable and thus balance the effects of lighter stocking, a large investment might also be risky. The owners are doubtful about the value of investing in saltbush, particularly as they question the decline expected by the agronomist who surveyed the pastures.

Income is satisfactory on case farm 3 where there is grazing, large-scale cropping and opportunistic buying and fattening of lambs. However, unlike case farms 1 and 2, this farm has large debts, and boosting cash flow is a priority. Stocking rate on the 500 ha of native grassland is falling, probably due to soil compaction. The property is already intensively run, and the future farm business is likely to be similar unless alternative enterprises are found. The owner's plan to include most or all of the grassland in a crop rotation, as previously occurred in the 1960s. The alternative is to lighten stocking rate, which is consistent with public conservation goals.

Case farm 4 is a farm run by an elderly couple for whom current income from grazing and limited cropping is adequate. Grasslands of high conservation value cover 25% of the farm, occupying four different blocks of land. It is probable that the blocks will be sold off separately within 10 years, with land sale price

Table 2. The current economic and financial situation on the case study farms

| | Case farm | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Plains | | | | Hills | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Total capital ($'000) | 1,190 | 1,646 | 1,476 | 747 | 1,251 | 845 | 1,340 | 1,680 |
| Equity % | 88 | 82 | 87 | 100 | 95 | 85 | 100 | 100 |
| Economic performance | | | | | | | | |
| Expected operating profit after tax ($'000) | 14 | 32 | 72 | 11 | 18 | 2 | 28 | 10 |
| Return to capital % | 1.2 | 2.0 | 5.6 | 1.5 | 2.3 | 0.2 | 1.8 | 1.4 |
| Financial situation | | | | | | | | |
| Cash in (ie. income) ($'000) | 155 | 293 | 484 | 75 | 159 | 98 | 161 | 195 |
| Cash out ($'000) | 162 | 270 | 438 | 62 | 168 | 114 | 132 | 173 |
| Net cash flow ($'000) | -7 | 23 | 47 | 13 | -9 | -16 | 29 | 22 |

likely to be determined by expected returns from cropping.

The scenarios for the four case study farms on the hill country is somewhat different to those on the plains.

Case farm 5 runs sheep and cattle. Income needs to increase over time. Pasture investments on the better land classes are expected to make the most significant contribution. The owners will also fertilise the native pasture, but may continue to rotate applications rather than adopt the strategy of slowly building up fertility on selected areas with light annual applications as Simpson and Langford (1996) advocate. There is no intention of replacing native pasture, though advances in sowing technology or persistence of introduced grasses could change this.

Net farm income on case farm 6, which runs dairy and beef cattle, is very low and must increase substantially if the family is to stay in farming. The current program of more heavily fertilising dairy pasture is not likely to be adequate. Sub-dividing and fertilising a large native pasture paddock used by the dairy herd is expected to make a sizeable difference to net farm income, which might then be just at a level to provide for farm re-investment and to maintain the family. However, given their tight cash flow, the owners may have difficulty with this investment.

The owners of case farms 7 and 8 have a 'reasonable' income, but are concerned that they must keep increasing farm productivity to stay ahead. Pasture investment options available to case farm 7 are confined to the large areas of native pasture. The owners are keen to retain the native grasses and are embarking on a program of increasing production from this pasture by direct drilling clover seed, using fertiliser, and sub-division. They have accepted that the strategy will not yield significant benefits for several years. Options on case farm 8 include investments on both previously sown introduced pasture and on native pasture. They are embarking on the first, but are not yet convinced that the second is a realistic option.

In summary, there are clear differences between the properties in terms of alternative directions that the farm businesses might take, and some have more scope for management that is consistent with public policy goals than others. For properties on the plains, opportunities for investment on the farm are more likely to involve native grassland than other areas of the farm—either replacing the native grassland with cropping or changing its management by adding saltbush for example. On properties in the hills, there are more likely to be opportunities elsewhere on the farm, for example improving run-down pasture. On the hills, further investment in native pasture is also feasible without destroying its base of native grasses, though quick returns are not possible.

Where small areas of high conservation value are of concern then there is likely to be less difficulty in identifying an acceptable farm investment strategy that allows its conservation while still increasing income. This can be most clearly seen for the four hill farms. The conservation options and the areas they would apply to are shown in Table 3. The options are to retire land from production, rest land for 6-12 weeks a year, and sub-divide small areas out of a large paddock. Estimates of the affordability of the conservation options are shown in Table 4. It might be difficult to identify such a strategy on newly purchased properties and others that are heavily in debt.

Table 3. Conservation options

| | Case farm | | | |
|---|---|---|---|---|
| | 5<br>ha | 6<br>ha | 7<br>ha | 8<br>ha |
| Retire land | 50 | 30 | 27 | |
| Rest land for<br>6-12 weeks a year | 100 | 15 | 27 | 40 |
| Sub-divide and rest | | | | 60 |

## Implications for policy and extension

Five levels of opportunity for targeting policy and extension towards natural resources on farms are suggested. These are: the site-specific (paddock), the production systems, the farm business, the ownership and management of the farm business, and off-farm networks (Table 5).

The site-specific level relates directly to the area of conservation or land management interest. Questions about policy and extension must start, but not end, here. At the other end, focussing attention on the decision-maker is important not least because that person(s) may change. Further, the decision-maker is influenced by off-farm networks such as the local community, farm advisors, policy makers and players in the marketing chain (from inputs to end-products).

Table 4. Affordability of conservation options - expected after-tax farm operating profit

| | Case farm | | | |
|---|---|---|---|---|
| | 5 | 6 | 7 | 8 |
| | $'000 | $'000 | $'000 | $'000 |
| Whole farm - without investments | 21.0 | 1.8 | 24.1 | 21.8 |
| Investments - rest of farm | | | | |
| Direct drill - grass & clover | 6.4 | 2.8 | | 5.7 |
| Fertilising pasture | | 8.1 | | 4.9 |
| Irrigation | 3.1 | | | |
| Investments - native pasture areas | | | | |
| Fertilise only | 3.6 | | 4.5 | 8.7 |
| Direct drill - clover & fertilise | | | 8.3 | |
| Sub-divide & fertilise | | 4.8 | | |
| Whole farm - with investments | 34.2 | 17.5 | 36.9 | 41.0 |
| Conservation options | | | | |
| Retire land | -2.3 | -0.5 | -1.3 | |
| Rest land for 6-12 weeks a year | -1.7 | -0.4 | -0.5 | -1.6 |
| Sub-divide and rest | | | | 2.0 |
| Whole farm - with conservation options | 30.2 | 16.6 | 35.1 | 40.6 |

Changing production systems on the farm, not just the site of interest, may lead to better public outcomes. Possible changes on the case study farms include increasing rotation of stock so as to rest pastures, planting saltbush to take pressure off pastures, and consideration of native grassland issues in planning crop-pasture rotations. Incentives to change the grazing system further away from set-stocking and more towards rotational grazing may be appropriate, and could include reimbursing any direct costs associated with making the shift, support in learning new management and pasture recognition techniques, motivational rewards, and possibly tax deductions.

Table 5. Target for conservation initiatives

| Ultimate target | Proximate target |
|---|---|
| Site of public interest | Production system<br>Farm business<br>Owners and managers<br>Off-site networks |

The farm business level places the management of the native grassland in the context of farm business goals and how all resources, including labour and capital, are utilised. Developing an appropriate policy and extension approach requires information about what business strategies might be available that meet, or more closely reconcile, public and private objectives. However, incorporating environmental issues into farm planning alone is unlikely to be adequate. While standard farm management texts place a great emphasis on planning (Boehlje & Eidman 1984), capabilities and competence may be equally if not more important. Drawing on recent economics literature (Crosthwaite 1999), three important aspects of enterprise behaviour are important in considering appropriate policy and effective extension. These are:

- discovery or creation of opportunities, and taking advantage of and anticipating new situations;
- significance of routine (good and bad habits) in maintaining stability and success of the organisation; and
- capabilities and competencies available to the enterprise, including coordination skills, effectiveness in the use of time, adapability and how managers learn from their experiences.

Arising from these considerations are four broad areas to which public assistance might be directed in the case of farms with resources of public interest: creating opportunities, developing business skills, increasing capabilities and competencies, and providing a network of support. These are now discussed in turn.

Farmers need to be involved in the creation and elaboration of strategies that might either reconcile public and private interest, or come close to it. At present this entrepreneurial role is largely left to the individual farmer, some of whom may engage farm management consultants or other advisors to assist in this role or who may attend PROGRAZE, Property Management Planning, Dairy Business Focus and similar courses.

Providing business planning courses as well as expert advice to targeted groups of farmers with native grassy vegetation, especially those with high conservation value sites, might be appropriate.

Once a farmer embarks upon a strategy, failure is always a possibility. Good business training that imparts skills in analyses (including budgeting), monitoring, goal-setting, planning, tactical decision-making and negotiation can help minimise the risk of failure.

Increasing the capabilities and competencies of farmers, and opening up avenues for them to draw on the expertise of others, lays the foundation for them to create new opportunities and to take advantage of and anticipate new situations. This may include reviewing the farm operator's routines and skills, many of which involve choices that are not made consciously. Some routines will be essential for the stability of the operation, while others are barriers to improved management.

Finally, creating networks of like-minded people or of those facing similar management issues is important for reinforcing implementation of the chosen strategy and of reviewing and revising it as required.

The solutions will vary from farm to farm. An illustration of how the approach outlined in this paper might work is shown in Table 6.

Table 6. How the approach might work for properties where investment in saltbush plantations has been identified as a strategy

The example is illustrative, and is not an unqualified endorsement of the role of saltbush.

Objective: successful establishment of saltbush and its use in the grazing system to help manage rangelands in a sustainable manner.

Possible actions:

- fund the establishment of saltbush and provide appropriate technical support;
- provide assistance to encourage effective integration of the plantations into tactical grazing management;
- monitor performance of the plantation, effects on livestock and pasture, and profitability;
- evaluate the owners' capabilities and business and management skills, and possibly provide targeted assistance to improve these skills;
- assist in development of a whole farm plan with physical and business planning elements;
- seek to involve the owners in appropriate support networks.

## Conclusion

New dimensions to the conservation and land management problem emerge when it is examined from the whole farm perspective.

It has been shown that the next best investment on the farm may sometimes be on native grassy vegetation, and at other times it will not be. It has also been shown that if a more profitable business strategy than the present one can be identified and successfully implemented, then any costs associated with conservation become more affordable. While identifying such strategies may not be easy, the message for land owners, their advisors and extension officers is to creatively think about different business strategies for the whole farm, and what place native grassy vegetation might have in them.

The message for conservation policy makers is to adopt approaches that assist owners to set new directions for the farm business or which change production systems across the whole farm. The problem does not have to be conceived in terms of payments to compensate for private costs. The problem is instead how the business can be developed while maintaining native grassy vegetation or other natural resources of public interest.

Although there is no guarantee of success, this approach is likely to both increase the prospects of lasting success and reduce the costs to government. In the case of farms with native grassland of high conservation value, there is no alternative to public involvement because grasslands are unique and there is the possibility of irreversible losses. The question is what sort of involvement. Here, the farm business approach can be treated as complementary to mechanisms like covenants, fencing grants and rate rebates.

A starting point in adopting this approach might be to set regional targets for the number of farms with important native grassy vegetation receiving on-going business advice, funded initially through government programs in conservation and land management.

## Acknowledgements

The case studies on which this paper is based were undertaken as part of a project jointly funded by Environment Australia and the Land and Water Resources Research and Development Corporation. The project was also supported financially by the Victorian Department of Natural Resources and Environment and by in-kind support from NSW Agriculture. Full project reports are available on the web site:
http://www.landfood.unimelb.edu.au/research/grass_eco/

## References

Boehlje, M. D. & Eidman, V. R. 1984. *Farm Management*. John Wiley and Sons, New York.

Crosthwaite, J. Natural resources policy and the behaviour of firms. In: *Grounding the Paradigm*, Australian New Zealand Ecological Economics Society National Conference. Griffith University, Queensland.

Crosthwaite, J. & Malcolm, B. 1998. *An economic analysis of native pasture in the hills and tablelands of south-eastern Australia*. Institute of Land and Food Resources, The University of Melbourne, Parkville, Victoria.

Crosthwaite, J. & Malcolm, B. 1999. *An economic analysis of native grassland on the Riverine Plain of south-eastern Australia*. Institute of Land and Food Resources, The University of Melbourne, Parkville, Victoria.

Department of Environment, Sports and Territories 1996. *The National Strategy for the Conservation of Australia's Biological Diversity.* Department of Environment, Sport and Territories, Canberra.

Department of Natural Resources and Environment 1997. *Victoria's Biodiversity: Directions in Management.* Department of Conservation and Natural Resources, Melbourne.

Makeham, J. P. & Malcolm, L. R. 1993. *The Farming Game Now*. Cambridge University Press, Cambridge.

Simpson, P., & Langford, C. 1996. *Managing high rainfall native pastures on a whole farm basis.* NSW Agriculture, Orange, NSW.

# Marketing opportunities

Geoff K. Watson

Orange Agricultural College, The University of Sydney
Orange NSW 2800
gwatson@oac.usyd.edu.au

The cost/price crisis currently confronting Australia's grassland producers has defied some of the most creative thinking and responses that government policies and extension programs have initiated in recent times. This paper proposes that for some producers the keys to addressing the price dimension of their business lie in their own astute marketing strategies, which are, in turn, framed by the marketing arenas they choose to operate within. This framework of marketing arenas is initially outlined, followed by instances of new thinking and new action that typify entrepreneurial responses by producers to the opportunities that exist there for them. The risk factors and critical success factors that accompany these initiatives are also identified, since they provide an indication as to why these new strategies require significant strategic skills and commercial leadership.

*Keywords: producer marketing opportunities*

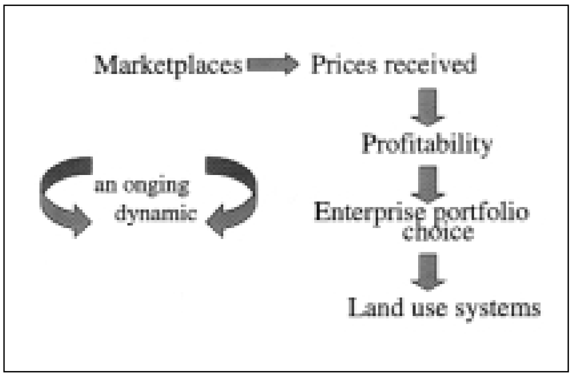
## Introduction

Marketing opportunities have always represented an ongoing dynamic for rural producers to seek out, evaluate and embrace. In certain situations they change the outlook of an industry so profoundly that producers are literally forced to adjust to them. The thrust of this paper focuses on developing a framework for analysing Australia's complex rural marketing landscape and then applying this framework to identifying opportunities for rural producer marketing. First though, it is important to forge a link between rural marketplaces and the environment, particularly grassy landscapes.

## Linking marketplaces with grassy landscapes

The key elements of this linkage are outlined in Figure 1. The linkage begins with the assumption that because rural production is fundamentally a commercial activity, rural markets are the places where the value created by specific rural products is determined and expressed back to producers through prices received. Market prices are, in turn, one vital component in the relative profitability of various rural enterprises. Therefore, rural producers are influenced by marketplaces in their choice of enterprise portfolio. Ultimately, enterprise portfolios become major determinants of land use systems, of which grassy landscapes are an example. One instance of this connection is the status of the wool industry marketplace. We will hear at this conference of the impact on land use systems of the long-term decline in viability of the Australian wool industry. There will be divergent views on whether these impacts are positive or negative, but it is highly likely that many will see the extent of these impacts as profound.

Figure. 1: Linking marketplaces with grassy landscapes



From a marketing and commercial perspective there is an important lesson here, that is, *no industry value chain has an innate right to continue to exist.* This right is earned day after day and year after year in a competitive marketplace, by continuing to provide superior value to final end consumers at acceptable profit and risk to major stakeholders in the chain (Lanning & Phillips 1991; Dept Primary Industries and Energy 1998). If any one of these just-mentioned criteria begins to be eroded, the entire industry chain can be threatened. Ultimately, the final consumer marketplace is frequently the stage on which the future of the industry is unravelled or re-stitched, since any viability issues for its stakeholders are reflected in the appropriateness of its product offerings. We turn next to consider what marketing is as a business and as an organisational process. This is an essential step in appreciating the role of marketplaces in providing rural producers with commercial opportunities.

## What is marketing?

The evolution of marketing as a concept makes instructive reading (e.g. Assael *et al.* 1995; Kotler *et al.* 1998) and is a reflection of the various commercial eras that Western society has passed through over the past century. We are currently in the era of 'strategic marketing', where competitive survival and advantage is as important as listening to customers and responding to what they say (Dunne 1999).

However, from a rural producer perspective, it is important to convey a clear message about the elements that comprise a marketing approach so that these elements can be analysed and effectively actioned. For this reason I put forward the definition of marketing in Figure 2.

Figure 2. What is marketing?

the right product
the right promotion
the right price
the right place and time
} to the right people

The role of this definition is to emphasise that marketing as an activity must produce a mix of strategy outcomes (e.g. product, price, place and promotion), which are driven by an understanding of target customer needs and wants. It is a selling approach, not a marketing approach, that says 'here is my product, now how effectively can I dispose of it?' A marketing approach begins with the customer and asks 'here are my target customers, how can I sustainably provide a mix of benefits that will be a superior value offer to them in a competitive marketplace and at acceptable profit and risk to myself?' (Lanning & Phillips 1991).

The second aspect of this definition is that marketing, like most aspects of human activity, is only meaningful when criteria are developed that create and define purpose. That is, it begs the criteria that in any given situation prescribe what is 'right' for customers (and, ultimately, for producers).

The difficulty for rural producers, as indicated to me at seminars and marketing courses, is that marketing in the terms described above is too challenging to implement. For instance:

- they are struggling producers not marketers;
- therefore they do not have the resources or time;
- nor the mindset, inclination or skills;
- they live in industries that are not focused on the customer anyway;
- it's really someone else's job; and
- they are getting older!

One response in the face of these comments is to suggest that a further framework exists that specifically covers rural producer marketing situations and allows rural producers to recognise opportunities that relate to the *way* they can approach marketing their products. We term this framework 'rural producer Marketing Arenas'.

## Marketing arenas

Marketing arenas are defined as: essential ways in which rural producers can choose to market their products. In this context we will focus primarily on how these ways of marketing (i.e. arenas) can assist producers to recognise and seize opportunities, and to appreciate the critical success factors they must work on.

The three arenas that form this framework are:

- the COMMODITY arena;
- the CONTRACT/ ALLIANCE arena; and
- the BRANDED PRODUCT arena.

I will define and give examples of these arenas then review them in terms of opportunities and success factors. More detailed discussion of the framework appears under NSW Agriculture (1992) and Watson (1999). Other articles (Watson1995a; Watson1995b) further explore the issues of marketing opportunities for rural producers.

### The commodity arena

*Definition:* crops, fibres or livestock sold through selling systems for the 'price on the sale day', at a range of possible gradings and prices (see also Kondinin Group 1997).

Examples: saleyard cattle; wheat in various grades; fruit broadly graded and sold through central markets

*Some producer mindsets:*

'I sell to my selling system':

- I accept the auction price/pool price on sale day (or I hedge or take out an exchange traded option);
- someone else downstream in the selling system does the consumer marketing, therefore my role is 'production';
- the selling system will accept almost any quality grade I produce, at its going price, but good quality is not always rewarded;
- if I don't supply this season, the selling system will still be there for me next time, without penalty.

*Opportunities (including risk reduction):*

- reduce selling costs;
- improve forecasting and selling system information to optimise sale timing and prices;
- foster relationships with selling system stakeholders (e.g. agents) to improve strategy, especially when there are geographical price spreads;
- minimise price risk via disciplined selling plans and hedging/options strategies;
- networking ability with other producers to build sales/supply bargaining power.

*Critical success factors:*

- forecasting ability for;
  - long term/medium term industry outlook
  - short term fundamental supply/demand forces
  - short term technical price indicators;
- researching ability to;
  - obtain selling system and price information;
- networking ability to;
  - leverage supply power.

### The contract/ alliance arena

*Definition:* Products/services are supplied by rural producers to buyers (processors, wholesalers, resellers, retailers) on the basis of contracts, which typically specify volume, quality, delivery and price.

Examples: Beef quality alliances; producer-exporter contracts; vegetable processor contracts; contracts to cooperatives; lamb contracts to beef wholesalers/retailers; wine grape contracts to wineries.

*Some producer mindsets:*

'I have a key relationship with my buyer to physically supply my product on the basis of price, volume, quality and delivery':

- therefore it is important that I negotiate the best possible contract deal;
- even though someone downstream will still do the consumer marketing, my contract keeps me aware of consumer requirements;
- to retain my buyer relationship I need to fulfil my contract and be aware of any potential penalties;
- production and quality control are therefore vital.

*Opportunities including risk reduction:*

- building negotiating power and skills;
- partnerships/ networks to improve quality and timing;
- developing relationships as preferred suppliers; and
- reducing downside risk of not fulfilling contracts.

*Critical success factors:*

- negotiation skills to develop the best possible contracts;
- obtaining industry market information to evaluate the best buyer/ contract opportunities;
- relationship skills to develop long term, preferred supplier status;
- creating networks or more formal business partnerships with other producers to improve supply power, quality and timing;
- entrepreneurial leadership (particularly if other suppliers are in collaboration) to sense and respond to emerging opportunities.

### The branded product arena

*Definition:* Traceable products/services that carry the differentiating brand of the rural producer(s) accountable for the pricing, promotion and delivery to target customer segments.

Examples: Haddon Rig Merino Stud; Millamolong farm homestays; Batlow apples; Cassavene wool garments.

*Some producer mindsets:*

'With my brand on my product, I am accountable for creating, promoting and delivering the value at the right price, which will attract and keep my target customers and enable me to operate at sustainable profit and risk':

– therefore, it is important that I research my customer needs;
– it is important that I benchmark my business processes and maintain quality and customer service; and
– my reputation as a business marketer is totally linked to my ability to consistently and reliably supply this value to my customers.

*Opportunities including risk reduction:*

– niche markets not well served by commodity/contract players;
– creating the right relationships to secure competitive advantage;
– obtaining appropriate skills and advice to reduce risk.

*Critical success factors:*

– the full range of entrepreneurial skills, especially:
– skills for investigating customer needs;
– skills in preparing business plans;
– skills in managing/ promoting a branded product or service to a target group of customers.

## Using the three arenas framework to understand opportunities and critical success factors

The value of this arenas framework is that it provides rural producers with a map to assess opportunities, risks and critical success factors via the way they choose to market their product(s). Some key aspects to keep in mind are:

- none of the arenas offer a recipe for marketing success. They are all useful to rural producers once their appropriateness to the industry and strengths and limitations are understood;
- they can apply to marketing situations involving one producer or many;
- producers tend to operate in and look for opportunities in arenas that match their existing 'comfort zones' e.g. the commodity arena;
- when producers do consider moving from one arena to another they will encounter shifts in mindset/ new know-how and skills/ new tools and techniques/ new relationships to create and maintain. Typically such shifts pose a threat to existing comfort zones since they call for a different 'marketing hat'. To make these shifts, producers frequently need the incentives that emerge through different relationships with stakeholders in their value chain. One such relationship has been pioneered in Victoria by Castricum Brothers meats with lamb producers (Dept of Primary Industries and Energy 1997);
- some rural producers are adept at holding a portfolio of enterprises that are marketed across different arenas, e.g. Millamolong at Mandurama NSW (pers. comm.) may, simultaneously, sell wool at auction (commodity arena), prime lambs on contract (contract arena), and operate an international farm homestay (branded product arena);
- other producers may use the three arenas to market one enterprise, e.g. the MacSmith family in Central Western NSW (pers. comm.) may sell a percentage of their anticipated harvest of Canola on a forward contract, a further portion for the going price on harvest day, and brand sell a further portion as 'cold-pressed' '*Country Canola*' oil in bottles to retailers.

## Conclusion

This paper has looked at pathways for rural producers to consider in their ongoing search for marketing opportunities, and in understanding factors critical to their marketing success. With the benefit of a marketing arenas framework, rural producers can more effectively consider their overall approach to opportunity search rather than relying solely on the trends of the moment to guide them. The arenas concept is also useful in assisting producers to consider the mindset and skills requirements of moving to a different mode of marketing, especially when this threatens their personal marketing comfort zone. It also enables producers to gain a deeper understanding of the critical success factors as they move from arena to arena in their marketing approach.

## References

Assael, H., Reed, P. & Patton, M. 1995. Marketing: Principles & Strategy. (Aust. Edn). Harcourt Brace, Sydney.

Dept of Primary Industries and Energy 1997. Competitive Performance. Morescope, East Hawthorn, Victoria.

Dept of Primary Industries and Energy 1998. Chains of Success. AGPS, Canberra.

Dunne, T. 1999. Marketing Agricultural Products. Oxford, Melbourne.

Kondinin Group 1997. Profarmer Marketing Manual. Kondinin Group, Belmont WA.

Kotler, P., Armstrong, G., Brown, L. & Adam, S. 1998 (4th edn). Marketing. Prentice Hall, Sydney.

Lanning, M.J. & Phillips, L.W. 1991. Strategy Shifts Up a Gear. Marketing Oct.: 9-14.

NSW Agriculture 1992. Agricultural Marketing, Books 1 & 2. Alexander College, Tocal NSW.

Watson, G.K. 1995a. New Wardrobe of Smart Marketing Hats. Grow! Spring 1995:4-6.

Watson, G.K. 1995b. Opportunity Knocks With Smart Farm Marketing, Grow! Summer 1995:24-26.

Watson, G.K. 1999. Foundations of Marketing, Unit Study Guide, Module 1, Topic 3.

# Creating private markets for nature conservation

Carl Binning

CSIRO Wildlife and Ecology
GPO Box 284, Canberra ACT 2601
c.binning@dwe.csiro.au

This paper argues that private markets for conservation will need to be created to successfully conserve grassy landscapes. Australia has a national parks system of which it is justifiably proud. However, native grassy landscapes, which are generally privately owned within agricultural regions, are not well represented within Australia's national reserve system. A new approach is needed where individuals are encouraged to invest in nature conservation. In this area, Australia has much to learn from Europe and North America where governments are just one player in the nature conservation game.

The paper reviews current approaches to nature conservation and proposes a model 'Conservation Management Network' for coordinating conservation effort across land uses and tenures. Policies for putting a Conservation Management Network in place through partnerships with landholders are discussed. These range from legislative and legal controls to education and incentive programs. Emphasis is placed on getting the mix of policies right rather than focussing on any single solution.

Finally, mechanisms for encouraging private investment in nature conservation are discussed. The challenge of creating a philanthropic market is put forward, that is, encouraging direct investment conservation by concerned city dwellers. The role of conservation trusts and tax incentives in creating this market are highlighted.

Keywords: private markets, conservation, policy tools, conservation trusts, tax

## Introduction – the need for private sector involvement

There are a number of important drivers when considering the private and non-government sectors in developing successful approaches to the conservation of native grasslands. The first set of drivers relate to a fundamental shift in approaches to achieving nature conservation[1] outcomes:

- It is broadly recognised that many of our most vulnerable ecosystems (groups of native plants and animals) are found on land that is managed by private landholders. Examples include the temperate woodlands and grasslands of the wheat–sheep belt, and parts of the rangelands. Traditional approaches to public conservation through National Parks will not work in these regions. Rather, an approach that fosters conservation stewardship by individual landholders is required (Pressy 1995; Binning & Young 1997).
- Nature conservation is fundamentally directed at the conservation of biodiversity at all levels, that is, genetic, species and ecosystems. Loss of biodiversity is perhaps Australia's most urgent environmental problem (Commonwealth of Australia 1996). The protection of biodiversity requires a landscape approach where the protection of natural systems and the ecological processes that underpin them are effectively integrated with human production systems. A landscape approach to nature conservation demands a much broader set of strategies.

---

1 It is noted that the term nature conservation as used in this paper should be interpreted in the broad context set out here.

- Any approach to conserving natural areas requires effective engagement of regional and local communities and must be underpinned by strategies that maintain the economic viability and social vitality of regional communities.

For these reasons, it would be difficult to sustain an argument that new approaches to nature conservation are not required. The second set of drivers relate to the characteristics of the non-government sector and what they can add to the achievement of on-ground conservation outcomes:

- The non-government sector is independent and may be more successful in engaging private landholders in nature conservation programs. The experience of Trust for Nature (Victoria) would suggest this is indeed the case. Likewise, the employment of local landholders as extension officers is proving to be a highly successful innovation in many conservation programs (Lambert & Elix 1998).
- The non-government sector is large, powerful and diverse. The task of managing our natural environment is a complex and difficult task that cannot be left to governments alone.
- The non-government sector has greater scope to be innovative. Non-government organisations are often less constrained than government agencies and are better able to gauge community needs and to develop entrepreneurial solutions. An important niche exists for the non-government sector to be the innovators in conservation planning and program development.
- Free of bureaucratic processes, non-government organisations are often able to deliver on-ground outcomes more efficiently than government organisations. This is particularly true at local and regional scales where individual knowledge and networks are often critical.
- Finally, the non-government sector has scope to develop pragmatic solutions to nature conservation that are often outside the political reach of government institutions.

Nevertheless, governments also have played and will continue to play a critical role in planning for and achieving conservation outcomes. Governments are leaders and must establish the institutional structures that correct the failure of markets to adequately recognise conservation as a public good.

In the next two sections of the paper a conceptual framework for achieving conservation outcomes is put forward followed by a brief summary of policies and strategies for engaging private landholders in conservation before returning to the main topic: engagement of the private and non-government sectors.

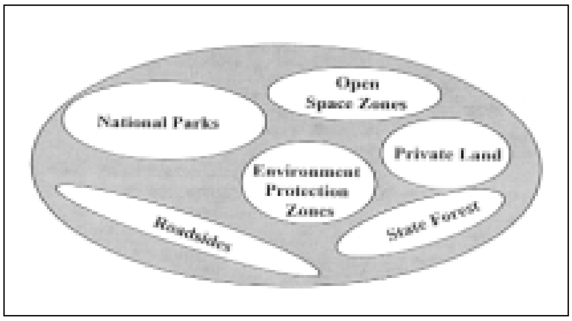
## Conservation Management Network - a conceptual framework

There are currently no mechanisms for accounting for and quantifying the contribution of the non-government sector in achieving nature conservation objectives. Lack of institutional recognition means that the contribution of private initiatives cannot be readily quantified. This is important for two reasons. First, it means that the role of private conservation is often neglected in the development of government policy at national, State, regional and local scales. Second, the poor public profile of private conservation impedes its future growth.

The concept of a Community Conservation Network has been developed to address this concern (Prober & Thiele 1996, 1999; Binning & Young 1997). Under this approach, all activities relevant to nature conservation are monitored and coordinated on an ecosystem basis across all land tenures. Some tenures, such as National Parks and local reserves, allow for conservation to be the exclusive land-use. Others, such as State forests and rural land, may require that land be managed for a range of purposes. The concept of a community conservation network is depicted in Figure 1.

The objective is to develop management strategies that maximise the contribution that each tenure of land can make to the achievement of conservation outcomes. No tenure is considered ‘superior’ to another. Rather, management strategies that maximise opportunities for integrating conservation objectives with other land-uses are actively pursued on all land tenures. For example, in the case of rural lands, conservation actions would need to be integrated with agricultural

Figure 1. The concept of a conservation management network



practices and the protection of corridors of native vegetation. The framework is inclusive and acknowledges that in many regions conservation objectives will not be met exclusively through formal reserves requiring greater integration between on and off-reserve conservation.[2]

The challenge is to operationalise the conceptual framework put forward through a community conservation network. This requires monitoring and recording the status of ecological communities across all tenures. A useful starting point would be to ensure that databases for recording both on an off reserve conservation data are effectively coordinated.

## Effective strategies and policies for working with landholders

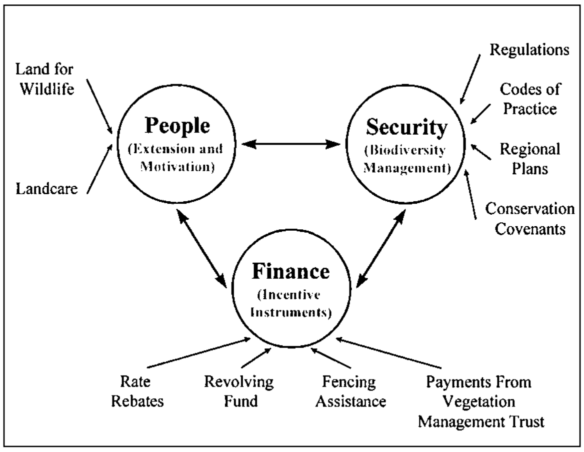
Ultimately, it is the actions of private land managers that will determine how effectively many of Australia's most threatened ecosystems, including grasslands, are conserved.

There is much debate on how effective partnerships may be engendered with private landholders. One approach, as exemplified by the Landcare movement, emphasises the importance of education and participation to raise the awareness and skills of landholders. An alternative approach seeks to establish minimum standards through regulation of the clearing and management of native vegetation.

Too often such policy tools are seen as competing mechanisms that should be offset against one another. Young et al. (1996) and Binning and Young (1997) find that a mix of these policy instruments are most likely to effectively conserve biodiversity by seeking to: address multiple land use objectives; retain landholder support; and manage for uncertainty and the prevention of irreversible loss. A framework that integrates the various mechanisms available for off-reserve conservation is shown in Figure 2. The core components of successful policy development can be characterised in the following way:

- People—the tools that can be used to motivate and retain landholders support for biodiversity programs;
- Security—the mechanisms that can be used to provide secure adaptive management of biodiversity; and
- Finance—the incentives that can be provided to share the costs of managing biodiversity.

Figure 2. Components of an effective policy mix for off-reserve conservation




The full range of tools identified in figure 2 is rapidly growing in Australia (Dore et al. 1999). Whilst work needs to be done, it is safe to conclude that the principle of using mixes of policy tools is well embedded. The challenge that remains is to more effectively engage the non-government sector, as alluded to in the introduction of this paper, in funding and delivering programs of this kind. It is to this topic that we now turn.

## Conservation trusts - a model for private sector involvement

If the non-government sector is going to be effectively engaged in grassland conservation on private lands, a new range of organisations for private conservation will be required. These organisations, known as Land Trusts in the United States, would be able to access the full range of conservation tools, including the capacity to raise funds through donations and corporate contributions, enter conservation covenants and buy and sell land under Trust. The experiences of one such US based organisation, The Nature Conservancy, is described in Box 1.

[2] It is noted that such a framework is not entirely new and is consistent with the approach used in the United Nations Environment Program's Biosphere Reserve model

## Box 1 The Nature Conservancy

The Nature Conservancy is a non-profit organisation established in the United States. The Nature Conservancy uses non-traditional market based solutions to protect land that is of high conservation value. The mission of the The Nature Conservancy is 'to preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and water they need to survive'.

The Conservancy currently operates the largest private system of nature sanctuaries in the world, with more than 1600 preserves in the United States. Originally, the Conservancy achieved its goal by simply purchasing land of high conservation value from willing sellers. However to increase effectiveness and to extend its role, the Conservancy now protects land through gifts, exchanges, conservation easements, management agreements, debt-for-nature swaps, and management partnerships (See the discussion of mechanisms).

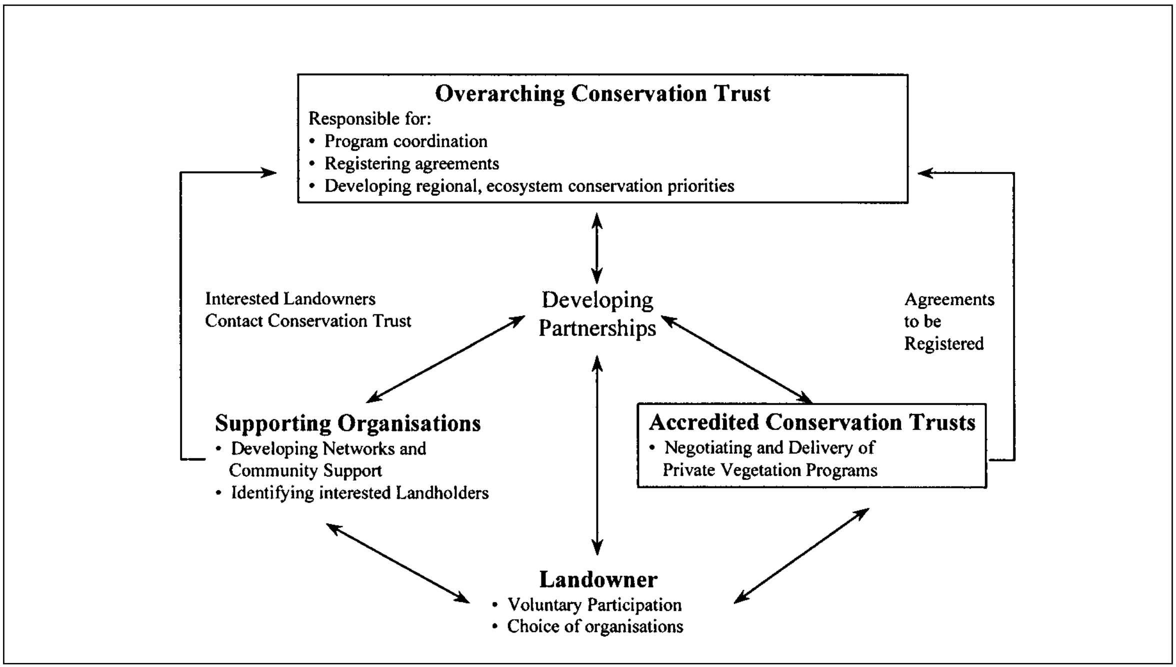
The Nature Conservancy now protects more than 9 million acres of ecologically significant land in the United States.

The Conservancy places primary importance on developing partnerships with landholders, businesses, academic institutions and government. Some examples are:

- Aluminium Company of America (Alcoa) and The Nature Conservancy signed a cooperative agreement in January 1996 that will result in the conservation and management of 1058 acres in Arkansas, USA;
- A partnership was established in 1996 between the New Jersey Chapter of The Nature Conservancy and a utility company called Public Service Electric and Gas Company (PS&G). Under contract the Conservancy is required to manage 16,000 acres of land owned by PS&G, which is home to 376 rare plants, animals and natural communities. 101 of these are listed by the State of New Jersey as endangered;
- Microsoft co-founder Paul G. Allen pledged to donate $5 million to The Nature Conservancy of Washington in January 1997 in the form of a Challenge Grant donated through the Paul G. Allen Forest Protection Foundation. The Foundation will donate $1 for every $2 donated to the Conservancy until the $5 million limit is reached. Allen's intention is to spur additional private donations to a total of $15 million.

Through innovative programs of this kind the Conservancy has become one of the top 10 charities in the United States. This demonstrates the increased importance of nature conservation to individuals and corporations, who between them provide 80% of funding for The Nature Conservancy. Whilst The Nature Conservancy is limited by a reliance on donations and investments, this has encouraged innovative ways of expanding the program. The Nature Conservancy's annual turnover is $450 million.

Figure 3. A model for establishing Conservation Trusts




Considerable progress has been made in promoting the use of conservation covenants in Australia. All States now have active covenanting programs, most of which are managed by State government agencies. Progress in achieving non-government access to covenanting powers has also been encouraging. Western Australia, through the National Trust, has recently established a program at arms length to government modelled on Victoria's Trust for Nature. Queensland and New South Wales are also in the process of considering the establishment of similar Trusts at arms length to government.

However, the weakness with all of the covenanting mechanisms in Australia is that they limit access to a single organisation, be it government or non-government. In no State is it possible for other organisations to access similar powers and develop other complementary programs. One possible way to address this impediment would be to develop enabling legislation that establishes clear criteria through which organisations could be accredited to access a range of conservation tools, including status to receive tax deductible donations and the ability to enter conservation covenants.

Two potential models for such legislation can be envisaged. The first model would involve the creation of an over-arching Conservation Trust with an independent board. This Trust would be responsible for holding a register of conservation covenants and for supporting and accrediting new organisations seeking to negotiate conservation covenants. The process of accreditation could be based on strict criteria relating to factors such as the organisation being not-for-profit and having a demonstrated capacity to fulfil its land management responsibilities. The second model would involve the relevant Minister providing approval to organisations who meet the criteria established under the proposed legislation.

The essential difference between the two models is whether governments or a statutorily independent Trust should be in the position of accrediting organisations and keeping a register of all agreements negotiated under the legislation. A related issue is which organisation should maintain conservation covenants entered by organisations that fail/lapse after a period of time. The core elements of the proposed approach are outline in Figure 3.

## Financial tools for creating private markets and philanthropic giving

A second factor that sets the US apart from Australia in terms of engagement of the non-government sector is the range of financial tools and incentives available to promote private conservation.

These tools are beginning to be used in Australia, but are limited in their application because of tax and other legislative impediments. Each of these tools is introduced below.[3]

### Basic ways of giving

- Cash donations—involves the capacity of a conservation organisation to receive donations from the public, corporations, philanthropic trusts and other charitable organisations.
- Donations of assets e. g. shares—involves the ability to make donations of property such as shares. The key issue with donations of this kind is the treatment of any capital gains.
- Donations of land—involves the donation of a particular kind of asset i.e. land. Of particular interest is when land of high conservation value is donated to a conservation organisation that agrees to protect and manage it in perpetuity.
- Bequests—involve the donations of assets or money in a will. Once again the key issue is the treatment of capital gains associated with any property donated.

### Mechanisms that involve conservation covenants

- Donations of conservation covenants—a conservation covenant is a restrictive covenant, in much the same way as a covenant protecting goodwill in a business. A key issue is if any change in the value of land arising from entering a conservation agreement would be tax deductible.
- Deducting costs of managing conservation covenants—businesses, such as primary producers, are able to deduct the costs of managing land from their income or claim a 34% Landcare rebate. A key issue is whether land covered by a conservation covenant should be given access to similar tax deductions.
- Negative gearing and primary producer status—based on a public interest argument, it has been suggested that people who buy and manage land for conservation should be given the same tax treatment as primary producers (conservation becomes a 'business' in this sense). This would allow land to be negatively geared and all costs associated with its management either depreciated or claimed as an outright tax deduction. The key issue here is whether taxation arrangements that apply to businesses could be carried over to conservation activities.
- Land taxes and local government—most classes of land are exempt from land tax and many rural areas enjoy lower differential rates. It would be possible to exempt land covered by a conservation covenant from Land taxes and Local Government rates
- Revolving funds—involve the purchase of land, placement of a conservation covenant that protects native habitat in perpetuity, and then resale to a willing landholder, thereby maintaining the organisations capital base. The Commonwealth government is committed to the establishment of revolving funds through Bush for Wildlife. Key issues include the ability to enter conservation covenants and access to exemptions from stamp duty and other charges associated with the purchase and sale of land.

### Other financing options

- Bargain sales of land—involves the sale of land to a conservation trust at a discounted price. In the United States, the gap between the full market value of the land and the sale price is considered a donation and is therefore tax deductible. Further, the portion of land value donated is exempt from capital gains tax. This is the single most effective private land conservation instrument currently applied within the United States.
- Landswaps and exchanges—involve a land trust exchanging land of high conservation value for land or other assets of a similar value. The key issue here is to ensure a capital gains tax event is not triggered through the acquisition and disposal of assets.
- Capital gains roll over for voluntary acquisition—when land is compulsorily acquired by government agencies the landholder enjoys a 12-month capital gains relief during which time they may acquire a replacement asset. This roll-over provision could be extended to land of high conservation value that is voluntarily sold to a conservation trust.
- Donation of land with retained right of occupation—land is donated to a conservation trust subject to the current owner being able to live on the property until they die. The key issue is the treatment of the donation both in terms

[3] The analysis contained in this section is drawn from the document Philanthropy – sustaining the Land prepared by Binning and Young (1999) in collaboration with the Ian Potter Foundation.

Table 1. Basic ways of giving

| Tool | U.S. Situation | Australian Situation | Changes Required |
|---|---|---|---|
| Cash donation | Cash donations are deductible and can be apportioned over 5 years | Cash donations are deductible only in the year they are made | Apportionment over 5 years |
| Donation of assets - e.g. shares | Deduction at full market value<br>Capital Gains exempt | Deduction at full market value from July 1 1999 | Capital gains tax exemption |
| | May be apportioned over 5 years | Subject to Capital Gains | Apportionment over five years |
| Land | Deductible<br>Capital Gains exempt | Deductible from 1 July 1999 | Capital gains tax exemption |
| | May be apportioned over five years | Subject to Capital Gains Tax | Apportionment over five years |
| Bequests | Exempt from capital gains tax | Exempt from tax | |

of tax deductibility and in terms of capital gains treatment.

- Financial options, annuities and trusts—a wide range of more sophisticated financial tools are used by land trusts in the United States. These include entry into options for the purchase of lands of high conservation land, payment of annuities to people who donate land or other assets, the use of tax free bonds, and sales of shares in conservation lands. These tools raise complex tax issues, but are given favourable treatment within the United States.

As noted, the application of many of these tools is limited in Australia because of tax and other legislative impediments. The current situation in Australia and the United States is compared in Tables 1 to 3, noting the changes in taxation arrangements required to achieve a level playing field with the United States.

## Conclusion: Actions required to engage the non-government sector

This paper has alerted to the need to foster non-government sector participation in the conservation of grassy landscapes. It has done so within a conceptual framework of working in partnership with landholders. Strategies for engaging landholders through a mix of financial, educative and regulatory instruments have been highlighted. It has been argued that these mechanisms are developing well in Australia. Further, there is an opportunity to better integrate on and off reserve management through the creation of Conservation Management Networks that coordinate management across tenures.

The significant gaps that have been identified in this paper are the effective engagement of the non-government sector and the creation of private markets for nature conservation. Lessons from the United States have been drawn on to identify a number of strategies for addressing these gaps. The paper is concluded by summarising these strategies in three recommendations put forward for consideration by decision makers.[4]

### Recommendation 1

To facilitate private sector involvement in nature conservation, put in place arrangements for the establishment of private conservation trusts. These arrangements should allow for the following in an administratively simple way:

- allow broad fund raising powers that allow for donations from individual or organisations, provided the donation is consistent with the objectives of the Trust;

[4] Once again these options are drawn from the document Philanthropy – Sustaining the Land (Binning & Young 1999).

Table 2. Mechanisms that involve conservation covenants

| Tool | U.S. Situation | Australian Situation | Changes Required |
|---|---|---|---|
| Donation of Conservation Covenants | Deduction of the difference in land value before and after the covenant is entered. | Not currently<br><br>May be allowable under existing gifting provisions if a statutory covenant is considered property.<br><br>Requires a test case. | Confirm current situation and make legislative changes if required. |
| Deduction of management costs | No | No - unless a primary producer | Give access to the 34 % Landcare rebate to land covered by a conservation agreement |
| Negative gearing and primary producer status | Not Applicable | No | Allow negative gearing of properties covered by a conservation agreement<br>Give landholders who enter conservation covenants primary producer status for tax purposes |
| State Government land tax | Exempt in many, but not all, U.S. States | No exemption provided | State governments would be required to exempt land covered by a conservation covenant |
| Local Government Rates | Exempt in many, but not all, U.S. States | A small number (less than 15) local governments provide rate exemptions<br><br>NSW Voluntary Conservation Agreements are exempt from rates | State governments would be equired to exempt land covered by a conservation covenant |
| Revolving Funds | Exempt from land sales taxes and charges in some States | Only Trust for Nature (Victoria) and State agencies are currently exempt | Allow Conservation Trusts to enter conservation covenants<br>Exempt registered Conservation Trusts from taxes and charges associated with the purchase and sale of land |

Table 3. Other financing options

| Tool | U.S. Situation | Australian Situation | Changes Required |
|---|---|---|---|
| Bargain Sale of Land | Deductible<br>Capital Gains exempt<br>May be apportioned over 5 years | Current taxation arrangements do not allow for Bargain Sales | Allow the gap between sale price and full market value to be a tax deductible gift<br>Capital Gains exemption<br>Apportionment over five years |
| Landswaps and Exchanges | Does not trigger capital gains tax | Capital gains tax would be triggered by the disposal and acquisition of assets | Allow capital gains to be rolled over in negotiated land swaps |
| Capital gains roll-over for land voluntarily acquired | Proceeds may be reinvested in similar capital (i.e. land) within two years provided a government agency has committed to compulsorily acquire the land in the absence of voluntary sale | No arrangements in place | Allow capital gains roll over for properties voluntarily sold to conservation trusts |
| Donation of land with retained right of occupation | Donation of the value of the land is allowed over five years and is capital gains tax exempt | [Uncertain] | Allow deduction for the donation of land with retained right of occupation<br>Capital gains tax exemption<br>Apportionment over five years |
| Conservation annuities, bonds and shares | Receive favourable taxation treatment especially in relation to capital gains and estate taxes | [Uncertain] | Allow donations of the principle to be deducted over five years<br>Exempt from capital gains tax<br>Treat life time annuities as income |

- provide for conservation trusts to be placed on the register of environmental organisations that allows donations to be deducted from income;
- allow the conservation trusts to enter statutory conservation covenants that are legally binding in perpetuity and registered on the title of land; and
- allow existing conservation trusts to sponsor the development of subsidiary/accredited trusts that are given the same status as the parent organisation.

Recommendation 2

To facilitate greater private contributions, allow all donations of property to conservation trusts to be tax deductible over five years and exempt from capital gains tax. The definition of property for the purposes of this recommendation could be extended to:

- all land, physical and financial assets;
- conservation covenants;
- bargain sales of land, that is, the gap between sale price to the conservation trust and the full market value of the land;
- donations of land with the retained right to occupation of the existing owner; and
- donations of assets for which a limited lifetime annuity is paid.

Recommendation 3

To facilitate the creation of private conservation reserves, provide the following tax incentives to land covered by a conservation agreement:

- access to tax deductions, or the 34 % Landcare rebate, for costs associated with managing land covered by a conservation covenant;
- exemption from State land taxes;
- exemption from local government rates similar to NSW practice;
- exemption for conservation trusts from stamp duties, taxes and charges on the purchase and sale of land in the operation of a revolving fund; and
- allow private conservation reserves to be negatively geared and give their owners primary producer status.

## References


Binning, C.E. & Young, M.D. 1997. Motivating People Using Management Agreements to Conserve Remnant Vegetation. Paper 1/97, National R & D Program on Rehabilitation, Management and Conservation of Remnant Vegetation. Environment Australia, Canberra.

Binning, C.E. & Young, M.D. 1999. Philanthropy – Sustaining the Land. The Ian Potter Foundation, Melbourne.

Binning, C.E.& Young, M.D. 1999. Talking to the Taxman about Nature Conservation: Proposals for the introduction of tax incentives for the protection of high conservation value native vegetation. National R & D Program on Rehabilitation, Management and Conservation of Remnant Vegetation. Environment Australia, Canberra.

Commonwealth of Australia 1996. State of the Environment Australia 1996. Commonwealth Department of the Environment, Sport and Territories, Canberra.

Cripps, E., Binning, C.E. & Young, M.D. 1999. Opportunity Denied. National R & D Program on Rehabilitation, Management and Conservation of Remnant Vegetation. Environment Australia, Canberra.

Dore, J., Binning, C.E. & Hayes, G. 1999. Review of Best Practice Native Vegetation Management and Monitoring. Unpublished paper to ANZECC.

Lambert,J. & Elix, J. 1998. Grassy White Box Woodlands: More Than Just the Odd Tree. Report to LWRRDC and Environment Australia.

Pressy, R. 1995. Conservation Reserves in NSW: Crown Jewels or Leftovers. Search 26(2): 47-51.

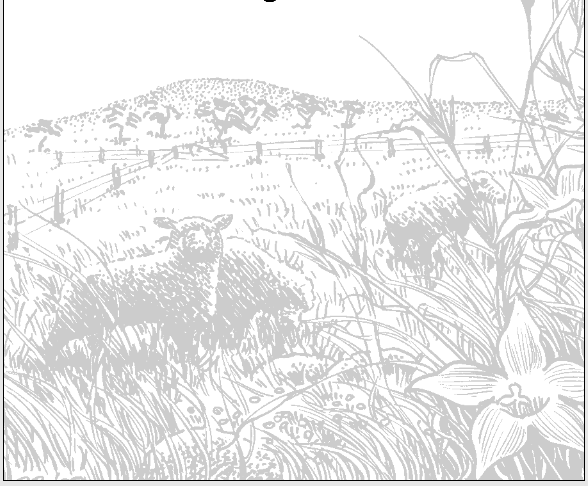
Prober, S. & Thiele, K. 1996. Reserve Concepts and Conceptual Reserves: the Grassy White Box Woodlands and Beyond. Unpublished paper.

Prober, S. & Thiele, K. 1999. A preferred model for the grassy white box woodland Community Conservation Network. Unpublished paper.

Young, M.D., Gunningham, N., Elix, J., Lambert, J., Howard, B., Grabosky, P. & McCrone, E. 1996. Reimbursing the Future: An evaluation of motivational, voluntary, price-based, property-right, and regulatory incentives for the conservation of biodiversity. Department of the Environment, Sport and Territories Biodiversity Unit Biodiversity Series Paper No. 9.

# Session 5

## Looking Back: Moving Forward



# Indigenous land management perspective on conservation and production

Adrian Stanley

Indigenous Land Corporation
GPO Box 652, Adelaide SA 5001
adrian.stanley@ilc.gov.au

Aboriginal people used grasslands as a source of food, primarily collecting seeds and utilising roots. The grasslands are also habitat for many native animals, which supplemented the seeds and roots as a food source. Aboriginal people burnt grasslands for several reasons, such as to open up 'country', cultural obligations, attracting grazing animals and promoting regrowth of grasses.

Aboriginal people are still utilising the grasslands. However, through the process of dispossession, Aboriginal people now have a somewhat different role and are managing 'country' differently. There is now a greater economic emphasis placed on the land whereas previously there was a balance between the cultural and economic spheres. In some regions land is now being returned to Aboriginal groups who are seeking to make a living from the land. In some circumstances the land is degraded and poor management practices of the past are clearly evident.

The future for Aboriginal people on the grasslands is held in knowledge and management. By passing knowledge on to the next generation, the combination of traditional knowledge and modern land management principles will give both Aboriginal and non-Aboriginal land managers tools to deal with problems in the future.

The Indigenous Land Corporation (ILC) has an important part to play in the future management of grasslands. The ILC's primary role is to acquire and manage land for Indigenous Australians. Some of the properties acquired by the ILC contain grasslands. Through this process and with cooperation between Aboriginal and non-Aboriginal land managers, the grasslands of Australia will be better managed.

Keywords: Indigenous, land management, Indigenous perspective

## Introduction

Australia is a unique country. We are blessed with some of the oldest rock formations, marsupials and monotremes, vegetation that is fire tolerant, and the oldest culture in the world. Indigenous people have lived in Australia for up to 60,000 years and the date may extend to 120,000 years (Roberts et al. 1994).

The time of arrival is always a point of discussion for many people. Indigenous people know how long they have been in Australia; it was from the beginning of time when Ancestors created the landscape. Indigenous people have utilised the country they live in and found new and inventive ways to live with the land rather than against it.

According to Horton (1981) there are approximately 492 language groups in Australia and the Torres Strait. There are differences between people and there are differences between beliefs. There is, however, one overriding belief that is transported throughout Indigenous Australia, and that is—you must look after 'country'[1]. 'If you don't look after 'country', country gets sick and if 'country' is sick people are sick' (Rose et al. 1996).

The Australian landscape is described as interactive, that is, it had to have continual human input for it to be functional and resource rich.

[1] The term 'country' in this context includes all of the landscape and the sea. This is the holistic view held by Aboriginal people which reflects the closeness of the Aboriginal people to the 'country'

Indigenous people utilised the land for food and subsistence, irrespective of whether the group was from the desert or the coast, the land and water was a constant source of food and had to be cared for.

Grasslands are one of the many land classifications that Indigenous people utilised. Grasslands are rich in biodiversity or in Indigenous terms 'good country'. There is a common belief that Indigenous people arrived from the North and stayed mainly on the coastal fringes where food, water and shelter were plentiful. It wasn't until later that Indigenous people moved to the inland regions of Australia. This movement coincided with the use of grinding stone tools to crush seeds into flour, which, when mixed with water, made a paste that was placed in a bed of coals and made into a damper-like substance.

The grasslands were habitat for many medium-sized marsupials and other smaller animals. The grasslands, like a lot of Australian vegetation, are accustomed to and tolerant of fire. Fire sometimes came naturally from lightning strike and was also often started by Indigenous people. The fire opened up country, made passage for people easier, assisted in the regeneration of plants, enabled animal movements to be easily traced and, in the months following the fire, new grasses grew and therefore it was easy to predict the movement of the animals that inhabited the grasslands. Another reason why fire was part of the landscape was because it was a necessity and a right as it was part of making country healthy.

## Present

Today the grasslands of Australia are still utilised by Indigenous people. However, the use is somewhat different now in that there is a demand made on the country for economic return. In the past, economic return was in the form of food, water and shelter. There is still this demand on 'country', however, now there is another demand—money. Past land management consisted of cultural, social and economic use—a balancing act, which is difficult to achieve.

Before European people came to Australia, Indigenous land management worked within the limitations of the land. European land management is profit-driven and therefore demands a lot more of the land than Indigenous management.
The principal reason for this is that conditions in Australia are vastly different to conditions where the European land managers had come from. The major differences are soil nutrient levels, rainfall and climate. When money comes into the equation some type of compromise or sacrifice has to be made, unfortunately at the expense of either cultural or social values. To make money the land suffers, which goes against all Indigenous Australians' belief systems.

Land that is given back to Indigenous people is usually marginal and isolated and, due to past management practices, 'country' is sick. Another issue of concern is that some of the areas given back to Indigenous people previously supported 3-7 people, but now must support up to 30 people. The repercussions of this are that stocking rates may be increased to compensate for the extra people. The 'country', being marginal and poor, cannot cope with this demand. The isolation or remoteness of some of the properties can result in additional problems such as poor health, poor housing and poor schooling.

For some Indigenous people, the grasslands were a route taken to another place and therefore they were not inhabited for long periods, unlike the situation today. Indigenous people are now living on the grasslands in permanent dwellings, communities and outstations. In tropical areas, the dwellings are inhabited seasonally, with a majority of people moving to towns in the wet seasons.

The grasslands were, and still are, a rich source of nourishment for Indigenous people. Quite often the same plants utilised by Indigenous people are now utilised to feed stock. When Indigenous people get land back and have to make a living from it, there is a factor encountered that was not experienced by non-Indigenous people. That factor is Indigenous 'culture'. Indigenous land management practices prior to European settlement were different to today. Land was burnt, 'country' was opened up and country was given time to regenerate. 'Open country is good country; closed country is rubbish country' (Bradley 1997). With practices of the past, 'country' could be rested. Now, most of the land needs to be used all of the time.

There is another issue of concern, and that is the loss of knowledge. With people not living on 'country' and travelling through 'country' less, the knowledge that was traditionally passed on is being lost. Knowledge is sometimes passed on as fragments and not as a whole picture, therefore this knowledge takes a lifetime to master. The danger is that parts of this knowledge will be lost and traditional Indigenous knowledge will be incomplete.
As land needs to be looked after so does Indigenous knowledge.

## Future

The future for grasslands is linked with knowledge. There are predominantly two types of knowledge systems held in land management: they are Traditional Indigenous knowledge and Western Scientific knowledge. The key to the future of grasslands in Australia is held within both of these knowledge systems.

Money-driven enterprises are changing to include social, cultural and environmental issues. There is a realisation that sustainable farming and management practices are the new way to manage land. There needs to be a combined effort from all parties involved in the management and use of grasslands, including Indigenous people, farmers, landholders, tourist operators, tourists, parks and wildlife agencies, conservation groups, scientists, and training and funding agencies. The onus is on the funding and training agencies, rather than on the Indigenous people, to include and inform Indigenous people of opportunities available to them. Sometimes agencies fail to acknowledge Indigenous landholders as stakeholders in their programs. One of the programs that is being implemented for use by Indigenous people is Property Management Planning.

For the process to be started, there really needs to be increased awareness of issues that face Indigenous people and non-Indigenous people alike. People need to be informed and advised of programs and resources that are available to them. Groups of people that use the grasslands need to be consulted. Recommendations need to be implemented and action taken—some of the best plans collect dust and are rarely implemented. There needs to be participation, both on the ground and at other levels. Agencies need to include and consult Indigenous people as stakeholders in the planning processes.

The Indigenous Land Corporation is part of the process of getting Indigenous people back to their 'country'. Whether the reason be economical, cultural, social or historical, these are insignificant if the system falls apart because of poor infrastructure and planning. Indigenous people need to be part of the process and included at management level, not just as landholders with an interest in the grasslands.

The combination of knowledge systems, inclusion of Indigenous people at management level, a voice, support from agencies, and implementation of management decisions are part of the process that will ensure the grasslands of Australia will be a viable commodity in terms of culture, economy, conservation and biodiversity.

## References

Bradley, J.J. 1997. LI-ANTHAWIRRIYARRA, people of the sea: Yanyuwa relations with their maritime environment. PhD thesis, Faculty of Arts, Northern Territory University, Darwin.

Horton, D. 1981. The Encyclopedia of Aboriginal Australia: Aboriginal and Torres Strait Islander History, Society and Culture. Aboriginal Studies Press for the Australian Institute of Aboriginal and Torres Strait Islander studies.

Roberts, R.G., Jones, R. & Smith, M.A. 1994. Beyond the radiocarbon barrier in Australia prehistory. Antiquity.

Rose, B. et al. 1996. Still our Country-Aboriginal Perspectives on Rangelands Management. Submission to the National Rangelands Management Working group for the National Strategy for Rangeland Management and Action Plan.

# Community perceptions of grassy vegetation[1]

Kathryn J.H. Williams

Department of Resource Management and Horticulture
Institute of Land and Food Resources
University of Melbourne, Parkville VIC 3052
k.williams@landfood.unimelb.edu.au

Management and protection of grassy vegetation is influenced by human beliefs, attitudes and values. Research into community perceptions is therefore an important tool for developing effective communication strategies in the interest of grassland protection. A recent project undertaken by the University of Melbourne investigated community perceptions of native vegetation in rural landscapes. Landholders and urban residents described their preferences for photographs of woodlands and grassland environments. The results indicate relatively high preference for grassy woodlands with eucalypt dominant canopy, but low regard for some other woodlands including those where the dominant canopy species is Buloke (*Allocasuarina luehmannii*). Treeless grassland also rated poorly. Low preference for these vegetation types can be attributed to a range of factors, including: poor understanding of the characteristics of healthy non-Eucalypt trees, false beliefs about the naturalness of treeless ecosystems, the cultural or symbolic importance of the gum tree, and inherited preferences for environments that appear productive and safe. This research suggests some new ideas for promoting the protection of grassy landscapes.

Keywords: preference, native vegetation, attitudes

## Introduction

There is no doubt that protection of remnant vegetation depends on good understanding of the biophysical processes of these ecosystems and the surrounding landscape. What is increasingly apparent is that effective management also requires good understanding of the social and economic factors that influence management of native vegetation (Price & Tracy 1996). Landholders' knowledge and attitudes have a significant and direct impact on management of off-reserve vegetation. Urban attitudes toward native vegetation also count. The balance we find between production and conservation of grassy landscapes will depend partly on the values of Australia's large urban population. Of particular importance is their willingness to support, through both public and private financial systems, the establishment of reserves, incentive schemes and education programs that encourage conservation. Our knowledge of community perceptions of Australia's biological resources therefore provides a powerful management tool. For this reason, Environment Australia and the Land and Water Resources Research and Development Corporation asked The University of Melbourne to examine how landholders and urban residents perceive native vegetation on private land.

Our attitudes toward native vegetation are shaped by numerous forces, some learnt, others innate. For example, Orians and Heerwagen (1992) have described some inherited responses that influence contemporary attitudes toward vegetation. Our landscape preferences, they argue, reflect an innate attraction to environments that appear safe and productive. They assume that evolutionary development of the brain occurred while humans lived as hunters and gatherers in the savannah environment of East Africa. The members of the species most likely to survive and reproduce were those who chose to settle in landscapes that provided for basic human needs such as shelter, food and water. In the African savannah, widely spaced trees indicate a source of shelter and

[1] The research described in this paper was undertaken in collaboration with John Cary, now with the Bureau of Rural Science, and Robert Edgar from The University of Melbourne.

suitability for hunting. Innate attraction to such landscapes provides an evolutionary advantage for hunters and gatherers; the processes of natural selection have ensured that such responses influence the attitudes of humans today. International research demonstrates landscape preferences that are consistent with this theory. Open landscapes with a smooth and easily traversed ground cover are highly preferred by most people (Kaplan & Kaplan 1989; Kaplan *et al.* 1989). While this approach provides encouraging news concerning human response to savannah-like grassy woodlands, one might expect that grasslands without trees would be considered unattractive.

Our perceptions of native vegetation are also influenced by social norms and expectations. Nassauer (1995) has examined people's responses to gardens with mowed and unmowed prairie grasses. She argues that both rural and urban communities expect well managed properties to be neat and tidy. Properties where native vegetation has been maintained in a relatively natural state (with scrubby understorey or long grass) may be considered uncared for and the owners judged to be poor stewards. For this reason, unmowed native grassland is likely to be viewed unfavourably during much of the year. Work by Lamb and Purcell (1990) contains a similarly discouraging message for those promoting the importance of protecting our native grasslands. They found that tall and dense vegetation was considered more natural than low, open vegetation. Cultural beliefs about naturalness shape our response to native grassland; landscapes with few trees are likely to be seen as somewhat unnatural and consequently to hold little aesthetic appeal.

Landscape preference theories provide insight to the types of native vegetation that may be preferred in agricultural landscapes. Photo-questionnaires are a useful method for examining perceptions of this kind and are a common approach to the study of environmental perception (Kaplan & Kaplan 1989). This approach often requires people to make simple preference judgements concerning photographic representations of various landscapes. By studying patterns of preference, one can identify the types of landscapes that people value and the criteria they use to assess these places. In the research described below, this technique has also provided a starting point for discussing beliefs and attitudes that influence land management.

## Study 1: Perception of woodland vegetation

This investigation of landholder and urban attitudes towards woodland remnant vegetation was conducted in 1997 and 1998. The study involved over a thousand residents of south-eastern Australia, including 568 rural landholders and 664 residents of Melbourne. The landholders were drawn from three regions: Victoria's Wimmera, the Midlands of Tasmania, and upper south-east South Australia.

Participants completed a survey regarding their preferences for photographs of native vegetation. The photo-questionnaire included 36 black-white images of native vegetation, selected from the areas in which landholder respondents lived. The scenes were chosen in consultation with local botanical experts to represent a range of values related to dominant species, spatial configuration and degree

Table 1. Mean preferences for vegetation categories: Comparison of urban and rural respondents

| Vegetation Category | Key descriptives | Mean Preference Rural | Mean Preference Urban |
|---|---|---|---|
| Dense Eucalypt Woodland | natural undergrowth vegetation | 3.30[a] | 3.26[a] |
| Open Grazed Woodland | open grazed cleared | 3.25[b] | <u>3.38</u>[b***] |
| Buloke Woodland *A. luehmannii* | fire dense natural | 2.84[c] | 2.80[c] |
| Grassy Woodland | grass native open | <u>3.36</u>[ab] | 3.34[a] |
| Sheoke Woodland *A. verticillata* | rocks/rocky dead dry | 2.96[d] | 2.84[c***] |

[abcd] For columns, matching superscript letters indicates no significant difference between preference for these vegetation categories

*** For rows, asterisks indicate rural and urban preferences are significantly different for this vegetation category.

of human modification of landscape (through grazing or wood collection). Respondents rated their preference for the scenes using a five point scale, ranging from 'I like this very much' to 'I do not like this at all'.

These preference ratings were used in two ways. First, patterns of preference were identified from the responses of all respondents. Through this process, five categories of vegetation were identified, suggesting perceptual characteristics that people might consider when assessing native vegetation. Second, mean preferences were calculated for each of the five vegetation categories. Follow up interviews and surveys provided further insight to perceptions of native vegetation. Participants described liked and disliked aspects of photographs that were typical of the five vegetation classes.

The results of this study are described in detail in Williams *et al.* (1998). Table 1 presents a summary, showing urban and rural preferences for the five vegetation categories. Three aspects of this research are particularly important for our management of grassy landscapes. First, the study indicates a moderately high preference for grassy woodland where the tree canopy is dominated by eucalypts. For rural landholders, these were the most preferred vegetation type. Landholders associated these landscapes with concepts such as stock, grass, feed and shelter. Our research provides strong evidence that landholders' aesthetic response to vegetation is strongly associated with its perceived value for agricultural production (Cary *et al.* 1999a) and this is reflected in the way landholders described these scenes.

Urban responses to grassy woodlands were distinct from those of rural respondents. Although these images were also moderately preferred, urban residents highlighted different characteristics of grassy woodlands. In particular, urban people tended to see this vegetation as typically Australian and picturesque. A higher proportion of urban residents appeared concerned by the long grass in some images, mentioning the hazards of snakes and fire.

A second important aspect of this study is the moderately high preference among urban people for woodland where the grassy understorey has been destroyed. Urban residents' most preferred scenes were those where heavy grazing and other processes had cleared the understorey and left widely spaced trees. They described these places as park-like, pleasant for walking and picnics. Relatively few urban residents appeared conscious of the associated loss in biological diversity. It is important to note that rural landholders viewed these landscapes much less favourably, were likely to describe these places as overgrazed, and to note the lack of understorey vegetation.

A final important aspect of this study is the finding that both rural and urban respondents express low preferences for Casuarina woodlands. This includes both the Buloke vegetation (woodlands dominated by *Allocasuarina luehmannii*, represented by sites in both South Australia and Victoria) and Sheoke woodlands (*Allocasuarina verticillata* woodlands found on rocky hill tops in the Midlands of Tasmania).

In examining responses to Buloke vegetation, the most obvious pattern to emerge from the interviews and surveys is a dislike of dense vegetation. A number of the most typical scenes in this category show relatively young, closely growing stands of Buloke. Urban and rural people described this vegetation as too dense for both agricultural and recreational functions. Density was not the only factor however, since respondents also expressed low regard for Buloke vegetation where trees were widely spaced and the understorey smooth and grassy. Respondents' comments also reveal quite a strong response to the form and foliage of the *Allocasuarina* trees. A number of landholders (23) described Buloke as scraggly, unhealthy, straggly, spindly, scruffy and providing no shade. One even referred to the 'dark satanic shapes' of the trees. Similarly, a number of respondents interpreted the dark bark of these trees as fire damaged. Low awareness of the species also appears an important factor in shaping perceptions of Buloke vegetation. Landholders expressing higher preference for Buloke were far more likely to name the trees as Buloke, Casuarina or Sheoke (Williams & Cary 1998). Poor understanding of some woodland species may contribute to misinterpretation of these plants as unhealthy.

In summary, the study found relatively high preference for grassy woodland with a eucalypt canopy, but low preference for grassy woodland with a Buloke or Sheoke canopy. The study also identifies a disconcerting preference among urban people for woodland vegetation where the understorey has been cleared. The findings overall are consistent with evolutionary theories of landscape preference, which predict higher preferences for landscapes that are relatively open and have a smooth understorey. The study also suggests some other factors that shape attitudes toward native vegetation. These include awareness of less familiar tree species, dislike of landscapes where trees are perceived to be unhealthy, and low awareness of the visual cues of land degradation, particularly among urban people.

## Study 2: Perception of grasslands

Human response to grassy landscapes, and especially to grassy landscapes with few trees, is a particularly fascinating issue for social science. This is because, almost without exception, the many theories predicting landscape preferences suggest that people will generally hold tree-less ecosystems in low regard. A second study provides insight to community perceptions of these landscapes. The study was designed primarily to identify whether landholders value native vegetation in landscapes that are obviously used for agricultural production. The study also investigated components of landscape preferences, including the perception of agricultural, aesthetic and ecological value in the landscape. It is very likely that landholders use multiple criteria to assess agricultural landscapes. By identifying some of the perceived values in the landscape, we are better able to understand landholders overall preferences for their own properties. Within this study we examined landholder response to both woodland and grassland vegetation in agricultural landscapes.

The landholders interviewed for this study were selected from respondents to the survey described in Study 1 above. A total of 131 landholders participated, selected from Victoria's Wimmera, the Midlands of Tasmania, and upper south-east South Australia.

Landholders examined 11 photographs of agricultural landscapes. The photographic images were full-colour and each landscape was based on an identical single landform. Three aspects were systematically varied: amount of remnant vegetation (none, small or large areas), presence of fencing, and associated land use (crop or pasture). In addition, one scene showed a native grassland.

Landholders assessed these images in four ways, each time using a five-point scale. They responded to the following questions:

1. How much would you like this paddock on your property? (Overall preference)
2. How valuable is this paddock for protecting native plants and wildlife? (Perceived ecological value)
3. How valuable is this paddock for farming? (Perceived agricultural value)
4. How attractive is this paddock? (Perceived aesthetic value)

Table 2 summarises landholder perceptions of agricultural landscapes with no remnant vegetation, with small and larger areas of remnant bushland, and with a large area of native grassland. The results confirm predicted low preferences for treeless landscapes. Landholders expressed low preference for having native grassland on their own property, but considered native grassland to be preferable to landscapes with no remnant vegetation. Native grassland was also perceived to have relatively low agricultural and aesthetic value and only moderate ecological value.

Landholders considered the aesthetic value of grassland to be significantly lower than landscapes with large areas of trees. This finding is consistent

Table 2. Overall preference, perceived agricultural, ecological and aesthetic values of four landscape categories.

| | No Remnant NativeVegetation (RMV) | Small area trees RNV | Large area trees RNV | Native grassland | |
|---|---|---|---|---|---|
| Preference for own property | 2.015$^{a}$ | 2.958$^{b}$ | 4.027$^{c}$ | 2.585$^{d}$ | Wilk's L(3,127) =.202, p=.000 |
| Agricultural value | 3.242$^{a}$ | 3.688$^{b}$ | 4.167$^{c}$ | 2.792$^{d}$ | Wilk's L(3,127) =.381, p=.000 |
| Ecological value | 1.336$^{a}$ | 2.405$^{b}$ | 3.815$^{c}$ | 3.130$^{d}$ | Wilk's L(3,128) =.087, p=.000 |
| Aesthetic value | 2.142a | 3.006$^{b}$ | 4.233$^{c}$ | 2.938$^{b}$ | Wilk's L(3,127) =.177, p=.000 |

a,b,c,d For each row, non-matching superscript annotation indicates means are significantly different with theories predicting low preference for native grassland on the basis of habitat requirements (Orians & Heerwagen 1992). Landholders also considered the aesthetic value of the grassland to be significantly greater than that of landscapes with only crop or pasture land cover. This finding is not entirely consistent with the work of Nassauer (1995) who predicted higher preference for neat and tended environments. The crop and pasture scenes provided strong signs of being tidy, managed environments yet landholders expressed higher preference for the relatively messy grassland environment.

A potentially important aspect of the study is the finding that native grassland was perceived to have only moderate ecological value. The ecological value of grassland was considered to be significantly less than that of landscapes with large areas of trees. In interpreting this finding, it should be noted that landscapes designated as having a 'large' area of bushland actually retained quite small remnants (around one sixth of the visible land). In contrast, the native grassland scene presented a very large area of remnant vegetation, albeit treeless vegetation. Current thinking in landscape ecology concerning management of remnant vegetation (Dramstad *et al.* 1996) would suggest that larger remnants are less open to invasion from exotic weeds and from clearing. Larger areas of remnant vegetation (including tree-less plains) would be highly valuable from an ecological perspective. Landholder response to the grassland scene suggests they have little appreciation of the ecological value of tree-less ecosystems, and little appreciation of the relationship between remnant size and viability. This finding supports the work of Lamb and Purcell (1990) who found that most people perceived low vegetation to be less natural.

## Discussion

In summary, this research suggests that community perceptions of grassy woodlands are quite positive where there is a eucalypt-dominated canopy. Perceptions of some other woodlands are less favourable, including those where the dominant canopy species is Buloke. The research also shows that native grasslands are generally not well regarded. There are many possible reasons for these perceptions. These include: poor understanding of the characteristics of healthy Casuarina trees, a belief that treeless landscapes are barren and unnatural, an Australian cultural preference for the symbolically important gum tree, and inherited preferences for environments that appear productive and safe.

These findings have some important implications for protecting and managing grassy landscapes, and also raise some critical issues for discussion. For example, one might question why Australian grassy woodlands are in such poor condition when community perception of grassy woodlands is apparently positive. It is important to note that while grassy woodlands were the most preferred vegetation type for landholders involved in this study, participants assessed only a small number of landscapes. The grassy woodlands presented in this study were only moderately preferred. Highly preferred landscapes, typified by managed parklands and scoring mean preferences above 3.8 on a 5-point scale (Kaplan & Kaplan 1989), may excite more protective management. Apparent inconsistency between perception and management outcomes may also reflect factors other than attitudes that influence human behaviour (Gardner & Stern 1996). While landholders value grassy woodlands, these ecosystems are principally valued for production purposes, particularly provision of shelter and feed. While in many situations landholders choose to retain these landscapes, other forces may intervene. One factor may be financial pressure to expand intensive enterprises. Another may be poor knowledge of how to manage grassy woodlands to ensure their long-term survival. Thus grazing pressure, use of fertilisers and other management practices may gradually erode the quality of these landscapes to a point where they are no longer viable. In the case of grassy woodlands, the community (or least the rural community) is likely to need little convincing of the value of these landscapes. Instead, community interventions should focus on the need for better management knowledge and practice, and for mechanisms which support less intensive management of these areas.

The situation for grasslands is quite different. Our research provides evidence that community perceptions of grasslands are quite different to their perceptions of woodlands. The long term protection of native grasslands is likely to require significant changes in community attitudes. In fact, one might wonder whether there is any hope of generating widespread community concern for treeless grasslands. Other research indicates attitudes can change. For example, research conducted in both Australia and New Zealand showed strong cultural differences in response to tussock inter-montane landscapes. New Zealand students expressed much higher preferences for these culturally significant landscapes (Cary & Williams 1999). A careful perusal of landscape perception research reinforces the hope that thoughtful design and management of grasslands may bring about change in community attitudes (see for example, Kaplan *et al.* 1989; Cook & Cable 1995; Nassauer 1995).

A final question requiring consideration is the validity of drawing inferences from human responses to photographic representations of grassy landscapes. People often express doubt as to whether photographs provide an adequate substitute for real environments. A number of researchers have studied this problem in the past by comparing responses to actual places and photographic representations of these places. Overall, the research shows this is a valid method (e.g. Shuttleworth 1980; Stamps 1990). When individuals view photographs, information visible within the scene is not the only factor that influences their response. Photographs prompt memories of direct experience of similar places, as well as more abstract knowledge of the environment. This knowledge and past experience contributes to the rich information obtained through these processes.

With regard to the studies reported here, there is reason for cautious interpretation of the results on two counts. First, Casuarina foliage is difficult to capture in a photograph and this may have contributed to negative perceptions of this vegetation. There is a possibility that the black-white photography used in Study 1 may have resulted in less valid assessments of this particular vegetation type. Second, the use of a single grassland image in Study 2 was an unfortunate (although in this case necessary) restriction. The appearance of native grasslands varies radically with season and management regime. The grassland image utilised showed a large area of long grass with no visible forbs, and the results of this study may well have been different were the grass shorter and a range of wildflowers visible. Further research is being planned to resolve these uncertainties.

## Implications for protection of grassy landscapes

The implications of this research for protection of native vegetation are dealt with extensively in Cary *et al.* (1999b). Four elements are particularly important to our discussion of balancing conservation and production in grassy landscapes:

1. There is a clear argument for interventions that target particular species and ecosystems in the interest of native vegetation retention. This study indicates the need for special approaches with regard to grasslands and Casuarina grassy woodlands. Educational approaches should raise awareness of these less familiar landscapes and challenge common misconceptions regarding these vegetation types.
2. There continues to be a strong need to provide an educational focus on the understorey or ground layer of plant communities, and this is as true for grasslands as for grassy woodlands. This approach is particularly important within urban communities, where there appears to be relatively little awareness of the importance of understorey plants. A related issue is the need to draw attention to the importance of young saplings in woodland environments. Few respondents noted the lack of regeneration in woodland environments or identified the link between regeneration of trees and remnant health.
3. As suggested earlier, the protection of grassy woodlands is perhaps most clearly dependent on management expertise and mechanisms to allow less intensive land uses. Landholders clearly appreciate the utilitarian value of these landscapes, but may have insufficient knowledge and capacity to manage these environments sustainably.
4. A final implication of the research is the potential for using designed landscapes to promote community concern for grassy landscapes. Strategies might include:
   - creating feelings of safety and coherence using built features, mowed paths and edges, and judicious planting of trees;
   - planting (unnaturally) high ratios of flowering plants to promote the feeling that a landscape is productive and attractive;
   - providing visual cues of ‘good management’ including high quality fences and signs; and
   - providing interpretative material regarding unusual plants and ecosystems.

## References

Cary, J.W. & Williams, K.J.H. 1999. Human perception of grassland environment and implications for protection of remnant vegetation. In: *Proceedings of the 1999 International Symposium for Society and Natural Resources.* Brisbane, ISSRM.

Cary, J.W., Williams, K.J.H. & Edgar, R.V. 1999a. *Perceived Values of Native Vegetation: A Simulation Study of Landholder Attitudes Toward Broadscale Landscapes.* Institute of Land and Food Resources, University of Melbourne.

Cary, J.W., Williams, K.J.H. & Edgar, R.V. 1999b. *Guidelines for Promoting Native Vegetation Protection.* Institute of Land and Food Resources, University of Melbourne.

Cook, P.S. & Cable, T.T. 1995. The scenic beauty of shelterbelts on the Great Plains. *Landscape and Urban Planning* 32: 33-39.

Dramstad, W.E., Olson, J.D. & Forman, R.T.T. 1996. *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning.* Harvard University Graduate School of Design: Island Press.

Gardner, G.T. & Stern, P.C. 1996. *Environmental problems and human behaviour.* Allyn and Bacon, Boston.

Kaplan, R., & Kaplan, S. 1989. *The Experience of Nature: A Psychological Perspective.* Cambridge University Press, Cambridge.

Kaplan, R., Kaplan, S. & Brown, T. 1989. Environmental preference: A comparison of four domains of predictors. *Environment and Behaviour* 21 (5): 509-30.

Lamb, R.J. & Purcell, A.T. 1990. Perception of naturalness in landscape and its relationship to vegetation structure. *Landscape and Urban Planning* 19: 333-52.

Nassauer, J.I. 1995. Messy ecosystems, orderly frames. *Landscape Journal* 14 (2): 161-69.

Orians, G.H. & Heerwagen, J.H. 1992. Evolved responses to landscapes. In: J.H. Barkow, L. Cosmides & J. Tooby (eds) *The Adaptive Mind.* Oxford University Press, New York.

Price, P. & Tracy, K. (eds) 1996. *National R&D Program on Rehabilitation, Management and Conservation of Remnant Vegetation.* Proceedings of a national workshop and project summaries. LWRRDC Occasional Paper Series No. 11/96.

Shuttleworth, S. 1980. The use of photographs as an environment presentation medium in landscape studies. *Journal of Environmental Management* 11: 61-76.

Stamps, A.E. 1990. Use of photographs to simulate environments: A meta-analysis. *Perceptual and Motor Skills* 71: 907-13.

Williams, K.J.H. & Cary, J.W. 1998. *Scruffy, scraggly, spindly: Landholder perception of remnant buloke vegetation*. Proceedings of ‘Wimmera Windharps – Bulokes for the Future’, Warracknabeal, Victoria, 23 July, 1998.

Williams, K.J.H., Cary, J.W. & Edgar, R.V. 1998. *Perception of native vegetation in rural landscapes: Implications for ecosystem protection and sustainable land management.* Melbourne Institute of Land and Food Resources, University of Melbourne.

# Rediscovering the past and making a future

Martin Driver

Greening Australia – Riverina
PO Box 1010, Deniliquin NSW 2710
gariv@clubworld.net.au

Historical journal case studies are used to give an appreciation of the early pastoral settlement management impacts on the ecology of the New South Wales Riverina. The degree of disturbance and fragmentation of various grassy woodland ecosystems are outlined.

The perception of the current landscape status as being 'natural' as opposed to an artefact of management is discussed. This perception, the natural productivity and relative resilience of the productive system, (combined with current rural economic trends) tend to mask the continued decline and fragmentation of the Riverina Plain mosaic ecosystem.

The role of awareness and understanding through extension as part of the delivery of financial incentives is seen as a core element to overcome this impediment. The process continuum of awareness, working with the willing, identification of issues, and delivery of incentives to reach nature conservation and production objectives is outlined.

*Keywords: history, degradation, rehabilitation*

It has been said that one definition of insanity is to do the same thing over and over and expect to get a different result each time.

If that is the case, then perhaps it is a sign of lunacy to not look back and understand and reflect on what actions have led us to a situation where large areas of the Australian agricultural landscape no longer function effectively. This lack of function is evident in ecological, hydrological and socio-economic terms. The sad truth is that we as a society, and agriculture as a collective industry, are effectively still doing the same thing—just with greater efficiency and effectiveness (without really looking back at what we've already done).

Because much of the degradation has been gradual, or were historical events beyond current living memory, much of the appreciation of change is lost. Each generation is numbed into a false sense of security that 'It's always been like that' or that 'It's not getting much worse' or, more frighteningly, 'What problem?'

One of the great difficulties in building an individual or community vision for a diverse, ecologically functional and agriculturally productive future is a failure to recognise how natural systems functioned and the degree of divergence from natural that presently exists.

Historical case studies of ecological changes are important because they:

- provide an historical benchmark for what existed at that site or region;
- offer examples of a known location and the degrees of change that have occurred at known locations (they are accessible, visible local sites);
- are dynamic and demonstrate the ongoing impact of management;
- demonstrate variations in the direction and level of change in response to management; and
- provide local understanding, learning and empowerment to act.

Historical case studies are not just an academic fascination or a romantic preoccupation with the past. They provide for:

- acceptance of past practises and understanding of their impacts;
- understanding of the pre-agricultural landscape and rates of change;
- understanding of the past and current issues, driving processes, repercussions and impediments;

- establishing the presence, condition and significance of remnants as skeletons to build upon; and
- a plan to attempt a systems reconstruction based on local landscape knowledge.

There exists a lot of individual and insightful historical references relating to vegetation status and changes from across the Riverina of southern NSW. I would like to use some excerpts from R.G.Kiddle's summary of 'Steam Plains' station journals, that were published in the Pastoral Review in 1931, to demonstrate the value of this sort of information. This reference is the most complete that I am aware of in terms of time coverage, vegetation detail, management practices and impacts relating to vegetation cover and composition changes.

*Steam Plains is an oblong block about 15 miles long by five miles wide, and consisted of open plain lands intersected by pine ridges and belts of timber, a wide, very shallow creek and various shallow lignum swamps, which in very wet seasons fill and overflow and form other shallow creeks. The pine ridges, or sandhills as they were called, were covered with a forest of Murray pines of all ages from seedlings to mature trees, interspersed with various kinds of acacias and similar trees, such as needlewood, wild irishman, hopbush, deadly nightshade, sandlewood and willows (cuba), and below these were numerous kinds of the smaller blue and salt bushes. In this condition the sandhills were not good as feeding grounds for sheep, as the grass was not as sweet nor as plentiful as in the open country. Also they were a great harbour for noxious animals, dogs and marsupials etc.*

*On the edge of the pine ridges and extending out onto the plains, in some cases perhaps only two or three hundred yards, and in others two to three miles, were timbered areas generally of a hard red soil, carrying grasses which were very sweet and quick growing after a dry period, and timbered with large quantities of edible trees, mostly boree (myall), cuba (willow), quandong and wilga etc. Beyond these timbered areas and sometimes amongst them were swamps timbered with box (eucalyptus) and gum trees, and the balance of the country was open plain interspersed with swamps and depressions, the biggest of which grow large quantities of lignum, growing in many cases 10ft. high. Such lignum swamps produced very little useful fodder. The wide shallow creek, generally dry, crossing the property was also heavily timbered with box, and it and similar box swamps produced very little grass. Towards the southern end of the run there occurred one large and two small swamps filled with a heavy growth of cane grass.*

*The open plain country, which when dry is either crumbly red or grey clay, and the open boree hard red country, were generally bush country with annual and perennial grasses growing around and between the bushes. These bushes consisted mostly of Old man saltbush, and considerable areas of bluebush and smaller saltbushes and cottonbush. At this time, taking a line from Narrandera to Corowa, which would run about 70 miles east of Steam Plains, the country all to the east of that line was forest country. Today, so much timber has been killed that, generally speaking, that forest line is now one hundred miles further to the east.*

*About 1850 fencing was started in the district and Steam Plains was fenced about then. This enabled more stock to be carried, but as a result the bush was more severely eaten during dry periods, and the less there was the more it was punished, so that by 1874 the bulk of the saltbush had been eaten out and killed and only certain areas of the cottonbush remained. The exception to this is that about 400 acres close to the homestead was preserved and still retains its original cover of Old Man saltbush and bluebush etc.*

*However, large numbers of sheep were successfully carried, for although the bush was gone the country was not eaten out, and responded to rains quickly; also thousands of edible trees were continually dropping edible leaves and branches. Large sums of money were spent in killing the box trees in the creek and swamps, and the sandhills were cleared of much useless scrub (needlewood, hopwood, wild irishman), and the pine trees were pollarded to a height of 8ft. These operations meant a largely increased growth of grass in the timbered areas. Further, the water supplies were improved and the lignum was cut and killed in the swamps. This period of improvement lasted approximately till 1897.*

*Rabbits were first known on Steam Plains in 1880, and in 1882, 29 scalps were paid for at 2s. 6d each; in the same year 884 kangaroos and 136 emus were paid for at 1s each. In 1890 the property was rabbit netted on the boundaries, and continual but ineffective methods of destroying the pest were adopted, and the whole district became very badly infested, it being nothing unusual to poison from ten to twelve thousand at one waterhole. The result was that during any dry period both the rabbits and sheep were underfed and the country was being eaten out. It was not fully realised what damage the* *rabbits were doing, but many of the edible trees were ringbarked and killed, and practically all bush and perennial grasses were killed.*

*In 1897 autumn was very dry, and over 13,000 lambing ewes were fairly successfully fed on branches of boree and cuba trees until June, when the season broke. The years of 1898 and 1899 were dry, and the country became very bare and started to drift. During 1900-1901 the rabbit burrows were all dug out and all rabbits destroyed, since when there have been practically none on the property.*

*Unfortunately, before the country could recover, the 1902-1903 drought started, and during that summer the whole country was in effect a moving sand-drift, with most netting fences and yards covered with sand. Blinding sandstorms occurred frequently, and many of the excavated dams were practically filled with drift.*

*As mentioned previously, in 1887 13,000 sheep were satisfactorily fed on the leaves and branches of boree and cuba trees. In places these trees were so thick that in mustering sheep it was not possible to see more than 300 yards, but generally the boree country was more open than that. About this time it was first definitely noted that the tent caterpillar (very hairy and living in woven bags during the day time) was attacking the boree trees and killing them by eating all the leaves. This caterpillar has continued its destruction, and 90 percent of the boree trees are now dead. A bushfire swept the property in 1918, burning many of the dead borees, and today it is practically clear country, where once it was possible to see only 300 yards. Though there is an abundance of young boree trees growing, which would soon reforest the country if protected from sheep, such precautions would only result in fostering them for the benefit of the caterpillar.*

*Today the sandhills are clear of all useless scrub and the pines have been considerably thinned out, and the two principal sandhills have been fenced in paddocks by themselves. The result is that during the growing season they produce a heavy crop of herbage, mostly crowfoot and barley and corkscrew grasses. Which can then be eaten, and the more suitable country reserved to a limited extent for summer use. The trees in the box swamps and creek have nearly all been killed, and most of the dead timber has disappeared. This part is now the heaviest carrying country on the property, the growth generally being a mixture of trefoil and barley grass. The boree country is now mostly very open and forms the main areas of the perennial grasses, such as whitetop and corkscrew, together with local herbage. The lignum swamps carry a good solo of herbages - mostly trefoil, barley, blue and small crowfoot.*

*The open plains, where it has been possible to treat them generously, are now well covered with cottonbush to an extent of about 12,000 acres, and are growing the usual herbage and grasses, while in several areas large quantities of wild oats grow in good seasons to a height of 3ft. and to an extent of several hundreds of acres. The cane grass swamps have been burnt at times and are now producing more feed than in the past.*

There are several very important points that can be gained from this reference. The first is that high levels of structural and species diversity (presumably including wildlife) existed during early settlement. There obviously existed a complex vegetation mosaic related to various Riverina soil types. There was also a high degree of perenniality, a range of age classes, and a high stored biomass relative to the rainfall and in contrast to the present vegetation cover.

The Riverina landscape was flat and easily settled. There was an apparently abundant supply of vegetation used for structural and fodder purposes. There also appeared to be an abundance of land to settle and 'improve'.

While many of these management 'improvements' were deliberate, some of the consequences were not. The outcomes that we now see as degradation were not a conscious decision to reach this end point, but the result of multiple impacts of small changes and subsequent responses. The action of fencing and set grazing was not (in most cases) intended to eliminate saltbush. And the belated recognition of the impact of total grazing pressure of sheep and rabbits on changes to the vegetation structure had a similar consequence.

The results of this management (deliberate or not) was to convert a perennial grassland/shrubland/woodland mosaic into a perennial grassland/shrubland (at best) or at worst an annual grassland with some perennial components. The resultant higher annual grass biomass effectively made the system more vulnerable to catastrophic wild fires, which in turn depleted the woodland component under set stocking.

This loss of perenniality has to a large degree impacted on both the ecological/hydrological stability and the production capability of this system under an erratic climate. Early set stocking management was effectively mining biomass without allowing any opportunity for replenishment of the system.

The grazing system is now subject to seasonal fluctuations in effective rainfall to a much larger degree than previously. Primary production is now concentrated on winter/spring biomass peaks related to rainfall and is not as effective in utilising summer storm events or intermittent rainfall. Therefore, the production fluctuations are further exacerbated making effective grazing utilisation problematic and prone to autumn feed gaps.

I won't go any further into the ecological and hydrological consequences of this level of vegetation disturbance and fragmentation. Suffice to say that they are significant and ongoing and the subject of an entire paper itself.

The loss of perennials and the ongoing decline in productive (and ecological) potential, and lower wool returns, have tempted many Riverina landholders to recently pursue intensification of production through annual cropping and pasture irrigation. The options are basically dryland grain crops, irrigated (deep bore) pasture, or rice. The former two are probably marginal and risky economic options, the latter showing tempting short-term profits. While not rejecting the development of appropriate scale irrigation, the danger is that it becomes uniform across the landscape. The irony is that it is still driving the system in the direction that we have done for 150 years—that is, losing perenniality and resilience, increasing vulnerability and lowering replacability (sustainability). Technology can maintain unstable systems, but at a cost. It also can often lead to non-irrigated areas being more intensively utilised because of the higher stock concentrations, leading to overgrazing and further loss of perennials.

While it may not yet be insanity, it is certainly approaching lunacy, to keep on doing what we have done in the past and not learn from our mistakes. We need, I believe, to have an individual and collective planned approach to structuring the landscapes of the future to integrate production and conservation objectives. We need to be sending the right messages as a community in the way of incentives and disincentives. Herein lies our current dilemma.

Ron Greentree, large-scale NSW wheat producer has been quoted in *The Bulletin* (13.7.99) as saying 'We have decided as a global community to sacrifice the environment to produce food and fibre for the standard of living we have chosen'. It would appear that somewhere along the line, Ron is picking up mixed messages, or that he just has selective hearing (or thinking).

While the current agricultural system does often maximise economic goals at the expense of the environment and social objectives, there are none-too-subtle cracks appearing. The objective of improving the extent and quality of native vegetation across the agricultural landscape is a stated aim of the government and an increasing desire of segments of the rural community. In the Riverina, Greening Australia (NSW) is trying to deliver a package of extension and incentives to help these people.

The first core elements of these programs are:

1. *Awareness, extension and understanding* – historical case study sites like Steam Plains and surrounding properties make excellent learning sites;
2. *Identification of issues and impediments and needs* – again local demonstration management sites are essential to show what is possible and what works, and able to demonstrate changes over time;
3. *Work with the willing* – work with those with a desire, empathy and capacity to actively manage their remaining vegetation;
4. *Provide appropriate incentives and support* – Greening Australia offers $1200 towards fencing costs, access to other appropriate support programs, up to $250/ha for site management, direct seeding and/or plant stock, technical support and advice and follow up.

The most important thing is not what native vegetation has been left within or at the edges of the agricultural landscape, but what is done with what is left. Active management, not passive neglect, is the key to the future of our natural systems. Appropriate management of seemingly highly degraded sites can result in significant conservation outcomes at a local level. In many cases there is no quantifiable negative production impacts because the areas of high conservation potential often coincide with the areas of the lowest production potential. In the Riverina, prior stream beds and associated sand dunes (as on Steam Plains) are the areas of most diversity, but subject to the most degradation under continuous grazing. Delineation of these areas with fencing to control grazing and appropriate weed control has the most potential to encourage regeneration. Many of the species listed in the Steam Plains reference will freely regenerate either from current fresh seed, soil seed stores or vegetative root suckering.

White Cypress Pine (*Callitris glaucophylla*) shows the greatest sensitivity to grazing, and therefore will benefit greatly from grazing control.

The harder red duplex soils adjoining prior streams can also respond positively to management. Total grazing exclusion may not be necessary though significant rest under rotational grazing will improve the density of perennial components (grass, shrubs and trees). Recovery of perennial native grasses is relatively quick (although the diverse herb layer may be largely lost in highly degraded areas for a long, if not indefinite, time).

The Boree (*Acacia pendula*)/Cooba (*Acacia salicina*) woodland component can regenerate from soil seed stores. This has been recorded even when there have been no living adult trees on the site for more than sixty years (pers. obs.). Stock exclusion is desirable during suitable germination conditions and the first few years of growth. The majority of young trees can reach maturity through an appropriate rotational grazing system that removes stock when grazing pressure is transferred to browse. The grazing regime can significantly influence the perennial structure of this system and the ratio between grassy and woody vegetation.

The development of a significant and diverse shrub component in the Acacia woodlands is entirely dependent on its starting condition and surrounding seed sources. Because of the early elimination of most of the saltbush species and their short-lived seed, only a few species (e.g. Thorny Saltbush *Rhagodia spinescens*) will readily volunteer into protected areas, provided there is a nearby seed source. However, this is where the greatest opportunity exists for direct seeding at least some elements of the shrub component back into former shrubland/woodland sites.

Re-establishing species like Oldman Saltbush (*Atriplex nummularia*) across the landscape has the twofold benefit (under appropriate management) of improving the landscape biodiversity values while at the same time improving the perenniality, and therefore sustainability for grazing. An added benefit can be the ability to defer grazing (because of the extra grazing provided by the saltbush) of other areas, allowing longer rest periods and even grazing exclusion of sensitive areas. Regeneration under appropriate management can occur once a seed source has been established.

Such a program can, in conjunction with other management changes, break the cycle of set stocking and continued degradation. This can then lead to a process of regenerating landscapes of increasing resilience, productivity and sustainability. Significantly, the change in management may, in many cases, only occur with the delivery of appropriate extension and demonstrations, access to incentives, technical advice, seed and machinery resources.

Mr Stanley, Government Veterinary Surgeon, wrote in ‘The Pastoral Times’ (Deniliquin) on May 15, 1886 – ‘*Cotton and saltbush were indigenous and required no cultivation in the old times, but it may be that having exhausted them here there may be some difficulty in again encouraging them to take to their old pastures; but as a matter of fact if we go into cultivation it would be better for us to grow cotton and saltbush than lucerne or hay… We have no doubt that plenty of roots and seeds are available on the back portions of the colony where the effects of excess feeding off are not so apparent as they are here, and that were small nurseries created here, it is likely that in a few years we would again have such valuable plants thriving vigorously on the local pastures. Is the experiment worth a trial?*’.

Let’s just hope that in another hundred years we are not repeating mistakes and have moved on to rewarding regenerative production systems based on sound ecological, social and economic goals.

## References

Hoy, A. 1999. The Great Wheat Hope. *The Bulletin*, 13 July 1999.

Kiddle, R.G. 1931. *Pastoral Review.*

Mulham, W.E. 1994. *The Best Crossing Place.* Reliance Press.

Stanley 1886. *The Pastoral Times*, 15 May 1886.

# A guide to best practice conservation of temperate native grasslands

James Ross

World Wide Fund for Nature Australia
GPO Box 528, Sydney NSW 2000
james.ross@bigpond.com

Effective conservation of the temperate native grassland communities in south-eastern Australia has proved difficult. Despite growing awareness of the important conservation values of native grasslands, slow progress has been made in securing permanent protection for remnants or even halting their decline. This 'problem' of grassy ecosystem conservation has prompted the development of some inspirational projects and new approaches to conservation that are of relevance to many agricultural landscapes.

This paper, based on a report commissioned by World Wide Fund for Nature, outlines the most successful methods developed for grassland conservation and develops a practical vision of the nature of landscape-scale temperate grassland conservation and the means for its realisation.

Recommendations for future action are based on the observations and experience of native grassland programs throughout south-eastern Australia. It is proposed that grassland conservation should concentrate on the protection of those sites of highest conservation priority for the community, species or region concerned. Specific targeted extension coupled with a range of protection mechanisms and appropriate incentives are the most significant elements in achieving long-term protection for these high priority sites.

Even where there is a clear recognition of the values of native grasslands by landholders and land managers, native grasslands on private and public land will continue to be lost or degraded unless action is taken to ensure their long-term security.

*Keywords: best practice, projects, conservation*

## Introduction

*'... a cataclysm has reduced landscapes of colourful, unique species-rich grasslands to a few small, scattered refugia, making these grasslands the most endangered natural ecosystems in Australia.' (McDougall & Kirkpatrick 1994).*

In the temperate lowland regions of south-eastern Australia, the natural grassy ecosystems have either been eliminated or reduced to small remnants. Temperate native grassland communities are regarded as requiring urgent conservation action in all regions in which they occur.

The decline in area and quality of native grasslands continues. Indeed, it is probable that the current rate of loss is the highest for several decades.

The main threats and impediments to conservation of the remaining native grasslands include:

- conversion to crops and introduced pasture;
- overgrazing by introduced stock;
- poor management of remnants;
- urban expansion; and
- invasion by exotic plants.

Threatening processes operate on both public and private land and are exacerbated by the common failure of landowners and government agencies to recognise native grasslands as native vegetation of conservation value.

The 'problem' of grassy ecosystem conservation has prompted the development of new thinking and new approaches that are of significance for nature conservation throughout agricultural landscapes in Australia.

This paper is based on a project conducted by World Wide Fund for Nature (Australia) (WWF) (Ross 1999a). The project aimed to develop a practical vision of the nature of landscape-scale temperate grassland conservation and the means for its realisation, based on the experience of the many projects and programs of the past decade.

## Conservation in productive landscapes

A dramatic shift in agriculture is occurring across the fertile plains of south-eastern Australia, from low-intensity grazing to more intensive use of land. With the support and encouragement of governments and industry groups, tens of thousands of hectares of new crops and pastures are being established in regions that contain the last remnants of the original native grasslands.

Although regulations are in place to limit or control clearing of native vegetation, land development continues to reduce options for biodiversity conservation in these regions.

It is apparent that many landholders still do not recognise the link between sustainable agricultural production and retention of threatened remnant vegetation. As a result, even where there are positive attitudes to remnant vegetation, those attitudes may not translate into action (Elix & Lambert 1997).

It appears certain that the existing threats to native grassland communities will continue and are likely to intensify. Even in those regions where there is currently little clearing in natural grassland landscapes, there is a constant and continuing threat of new technology, new crops, new weeds and changed market conditions. Pressures on the viability of farms will inevitably translate into pressures on native vegetation.

The area of high-quality native grassland remaining is a very small percentage of the total agricultural area. In the face of such uncertainty we must use legislative and planning mechanisms to secure these areas for conservation now.

## Grassland conservation programs

A decade of programs directed at addressing threats and achieving long-term conservation for species and communities has generated considerable interest in the conservation of native grassland communities throughout south-eastern Australia. Specifically these programs have:

- increased awareness;
- placed specific grassland extension and planning officers in most regions;
- provided biological surveys;
- protected a number of significant sites as conservation reserves;
- developed management agreements for sites on public and private land;
- identified benefits of native grassland for sustainable land management;
- increased knowledge of appropriate conservation management;
- included grassland communities and species in threatened species legislation;
- incorporated grassland conservation into regional planning processes; and
- placed the conservation of native grasslands on the conservation agenda.

In many respects, the effectiveness of these projects and programs has been unquestionable and there are numerous projects that have made substantial contributions to the conservation of native grasslands (Ross 1999a). However, most of these projects have aimed to increase community involvement and increase knowledge of the distribution and composition of native grassland remnants. With the notable exception of acquisition of areas for conservation reserves, few projects have been successful in achieving long-term protection for native grassland remnants or have adopted specific strategies to this end.

## Conservation objectives for temperate native grasslands

At present, all native grassland communities are considered to be ‘Critically Endangered’ or ‘Endangered’ across their range (adopting the taxon ratings of IUCN 1994). The massive depletion in area and fundamental changes in environment and management that have occurred since 1770 means that, even without further loss, these communities will always be threatened. The goal of grassland conservation should reflect this reality.

### Goal

Improve the status of native grassland communities to Conservation Dependent through permanent or long-term protection and management across their range.

### Immediate objectives for native grassland communities

- increased area of high priority native grassland permanently protected in conservation reserves;
- increased area of high priority native grassland on private land protected by covenants and long-term management agreements;
- increased area of high priority native grassland on public land protected by long-term management agreements;
- improved conservation management across all land tenures;
- increased community involvement in the management of native grasslands;
- increased knowledge of the distribution and composition of remnants;
- recognition of native grassland conservation in regional landuse planning and conservation strategies.

## Best practice conservation of temperate native grasslands

A systematic and comprehensive conservation program for temperate native grasslands will include five main elements:

- knowledge gathering and processing;
- priority setting;
- strategic planning;
- the means for conservation; and
- stewardship and management.

Few programs adequately address all these elements and it would appear that, without this comprehensive approach, on-ground outcomes could be limited or short-lived.

### Knowledge

Surveys of temperate native grasslands should identify and define sites, communities, species and features worthy of conservation on all land tenures. They should either assign a level of conservation priority to these features or provide a framework for making such assessments. Surveys should also be predictive of what may occur on unsurveyed sites, through analysis of flora and fauna with regard to environment and management (see Lunt 1995).

The most influential surveys for temperate grasslands have been:

- ‘landmark’ surveys that provide inspiration for broadscale action (e.g. McDougall & Kirkpatrick 1994);
- bioregional or sub-regional surveys across all land tenures (e.g. Diez & Foreman 1997; Sharp & Shorthouse 1996); and
- targeted surveys for particular features or programs (e.g. Maher & Baker-Gabb 1993; Barlow 1996).

Surveys will be most successful in leading to conservation outcomes if linked to extension programs and incorporated into conservation strategies. The Trust for Nature (Victoria) has consistently linked surveys of private land with regional programs, to good effect. Similarly, the instigation of WWF projects in the Monaro and South Australian Mid-North followed extensive surveys of those regions.

The current knowledge of the distribution and composition of remnant native grasslands in all regions is sufficient to undertake specific actions to protect high priority sites. Full inventories of sites or site characteristics are not a prerequisite for conservation action.

### Priorities

All remnants of native grassland are of value. However there is unlikely to be sufficient capacity in any region to protect all known native grassland sites through active means. Therefore, conservation programs should concentrate on the protection of those sites of highest priority for conservation of the community, species or region concerned (e.g. Prober & Thiele 1998).

Conservation priorities should be determined for sites based on the contribution they make to achieving immediate objectives and the overall conservation goal. The concept of ‘irreplaceabilty’ provides a useful basis for the design of reserve systems and the determination of conservation priorities (Pressey *et al.* 1995). Areas should be identified for establishment as public land protected areas in all regions, along with core areas or clusters of priority sites on both public and private land for complementary management.

A number of approaches are possible for assessing priority, including the use of focal species (Lambeck 1999), umbrella species (NSW NPWS *in prep*), iterative ranking according to threatened flora (Kirkpatrick 1983; McDougall & Kirkpatrick 1994), and the presence of particular features or communities (Owen 1997).

The Department of Natural Resources and Environment in Victoria is developing Guidelines for assigning priority to native grassland sites (see Muir 1996).

### Strategy

Lambeck (1999) provides an excellent summary of the two broad approaches to nature conservation in production landscapes. '*General Enhancement*' attempts to maximise the number of indigenous species retained or to minimise the number lost, within constraints imposed by other landuse objectives. '*Strategic Enhancement*' aims to retain identified components of the biota. It is strategic because it requires specification of landscape elements and the management regimes needed to meet a particular objective. Such approaches have quantifiable targets against which we can judge the effectiveness of our actions.

Grassland conservation demands the adoption of a strategic approach through concentrating on achieving protection for priority sites. These sites will become 'icons' for native grassland conservation that can be used to promote conservation management and act as a catalyst for grassland conservation in the broader landscape.

Strategies should always include specific outcomes with measurable indicators of success and performance targets to assess how projects meet immediate objectives. Performance measures should include the total area protected, number of management agreements completed, areas fenced, populations of significant species protected, managers of high priority sites met with, and so forth.

Strategies should also recognise that building relationships, trust and capacity within the community all take time.

Recovery plans developed for lowland grasslands in the ACT (ACT Government 1997) and being developed for the Plains-wanderer (*Pedionomus torquatus*) (NSW NPWS *in prep*) provide model approaches for written conservation strategies.

### Means

Two outcomes are necessary for permanent protection of remnants:

- a change in the land status, tenure or property rights of the land through reservation, purchase, covenants, or other permanent management agreements; and
- effective management of the land in perpetuity.

The means of achieving these conservation outcomes is through active involvement of people through targeted extension and education, mechanisms to achieve the change in land status or property rights, and incentives to undertake and maintain conservation management.

#### *People*

Well-delivered extension programs are fundamental to the success of all elements of grassland conservation: from collecting and disseminating knowledge to promoting the acquisition of reserves. However, extension programs must be directed towards achieving tangible outcomes if they are to be successful.

There are a number of excellent extension programs for native grasslands in south-eastern Australia. The majority are operated by Non-Government Organisations such as WWF, Greening Australia and Trust for Nature (Victoria). In areas where these extension programs are operating, knowledge of grassland conservation is low and there are few government extension officers.

Extension programs should aim to generate long-term protection for high priority sites on both public and private land. All extension programs should have access to suitable incentives for maintaining or adopting conservation management. Grassland extension programs should run for a minimum of three years, although longer periods will often be needed to secure long-term conservation and to ensure that knowledge is transferred to the community.

Extension is a specialist task requiring an understanding of community dynamics and personality types. There is some value in using local people as extension officers, but much will depend upon the skills of those people and their standing in the local community. Trust, local knowledge and continuity of advice should be maintained by ensuring that the same extension officer is employed throughout the duration of the program.

Greening Australia has developed a program called 'Learning from Farmers' whereby conservation-minded farmers encourage other landholders to adopt similar practices. Similarly, the Grassy White Box Woodland project of Community Solutions has recently employed four local landholders as Action Liaison Officers.

A number of themes can be drawn from the experiences of grassland extension projects to date:

- Only talk to landholders or managers in the grassland concerned. '*If they can see the native grassland once, they can't NOT SEE IT in the future*'.

- Use 'cold calling' to target owners with significant remnants.
- Always ask people what they know about the site first, how they manage it and why they value it.
- Use maps of the original and current distribution of native vegetation to demonstrate the significance of remnants.
- Develop messages that are appropriate for native grasslands and native pastures.
- Farmers may have limited knowledge about native flora, but conservationists often know less about farming.
- Build capacity within communities by 'training the trainers'. Use other groups such as Landcare and Field Naturalists to educate the community.
- There is a lack of trust between 'the conservationists', 'the government' and 'the farmers'.
- When sites are destroyed, use this in a positive way to encourage protection of other remnants.
- Actions speak louder than words: the educational value of on-ground projects should not be underestimated.
- Promote the diversity and naturalness of treeless grasslands.
- Be clear and honest about what you are trying to achieve, what you would like landholders to do and how you can help them.
- Most landholders require practical advice on identification and management of remnants.
- Non government extension officers will usually be more successful for private land conservation.

*Mechanisms*

Even where there is a clear recognition of the values of native grasslands, sites will continue to be lost unless mechanisms are available to ensure their long-term security. A range of protection mechanisms including reservation, acquisition, covenants, easements and other land management agreements is required, backed by incentives to encourage voluntary partnerships to protect biodiversity on and off reserves.

Regional plans are one approach to meeting broad vegetation management objectives. However, they must include suitable criteria for biodiversity conservation if they are to be effective. Acceptable levels of agricultural development should be set in each region with requirements for biodiversity conservation and sustainable land use underpinning those decisions.

Regulations to prevent clearing of native grasslands are an essential 'safety net' in all regions. However, regulations on their own will not bring about or maintain the long-term management necessary to protect biodiversity. A 'duty of care' approach will also be inadequate by itself, as many significant areas will require specific actions that go beyond this duty.

The development of management agreements including covenants and easements that secure long-term conservation for significant areas are crucial for grasslands conservation in all regions. Many landholders will, with some encouragement and assistance, readily set aside areas for conservation of native grasslands, especially on relatively unproductive parts of their properties. However, considerable extension effort and innovative incentive schemes may be required to secure agreements over relatively large or potentially productive areas.

The perceived unsuitability of some existing protection mechanisms may suggest the need to develop new approaches. The use of easements in Australia has not been explored to any great extent, yet overseas experience would suggest that they are an ideal mechanism for grassland conservation. Generally speaking, conservation easements are used to 'purchase' development rights over land to retain certain features. Most easements are voluntary and can be for a fixed term or can operate in perpetuity.

The number of privately owned native grassland areas that are a high priority for protection is sufficiently small that individual sites can be targeted for conservation in each region. [Crosthwaite (1997a) estimated that around three hundred to five hundred properties in south-eastern Australia support native grassland with high conservation values.]

Long-term management agreements should also be used to pursue conservation objectives on public land. A notable example of such agreements is the Memorandum of Understanding between the Department of Defence, Environment Australia and Environment ACT for the protection of threatened species and communities on Defence land in the ACT. Incentives, similar to those used on private land (such as fencing, management advice and surveys), may also be used to obtain long-term management agreements for public land such as cemeteries and Travelling Stock Reserves.

Most bioregions that support temperate native grasslands have relatively low reservation levels and, with few exceptions, high levels of bias within the existing reserve system (Thackway & Creswell 1995). There is a degree of urgency in improving the reservation status of grassland communities as land clearing continues to reduce options for biodiversity conservation.

In the past three years a number of highly significant grassland areas have been added to the National Reserve System. Together they represent the most important advance in native grassland conservation in south-eastern Australia. Despite the capital cost, there is little doubt that acquisition for conservation (whether by governments or private organisations) of large, relatively intact areas is the most effective means of ensuring long-term protection for native grassland communities.

As an example, the purchase of a property of some 1,280 ha supporting native grassland and grassy woodland communities at Terrick Terrick in northern Victoria, and its protection within the National Park system, has substantially improved the reservation status (and the conservation outlook) for a number of grassland conservation values (Lunt *et al.* 1999; Robertson 1999). These include:

- the largest area of Northern Plains Grassland in Victoria;
- the largest population of Plains-wanderers in Victoria;
- the largest known population of the Hooded Scaly-foot in Victoria;
- the only Victorian populations of Annual Buttons and Pepper Grass;
- possibly the largest Victorian populations of three other threatened flora species; and
- populations of a large number of flora and fauna species previously unrepresented within National Parks in Victoria.

Acquisition provides a level of certainty for grassland conservation that allows for long-term management planning and research. Just as importantly, it provides a presence for native grassland conservation in 'mainstream' conservation planning and public recognition of the importance of protecting these communities.

Purchase is not always an option, however. Cost and the vagaries of the open market can be limiting factors. More importantly, some owners simply have no interest in selling because of the site's value to their farming system, the potential loss of future opportunity, or a fear of what may happen to the land in government ownership (Gilfedder & Kirkpatrick 1995).

To facilitate the purchase of high priority sites for conservation, the necessary approvals and funding should be obtained on an in-principle basis—either for specific sites or for a class of sites so that conservation objectives are not frustrated by inability to act within the short timeframes of the open market. Non-government and statutory organisations have an important role to play in that they can act quickly and decisively to secure important grassland areas that become available for purchase and can negotiate openly with landholders.

Significant gains in reservation status can also be achieved by reviewing the status and management of public land areas: implementing mechanisms for long-term or permanent protection of high priority sites on public land should be a major component of grassland programs.

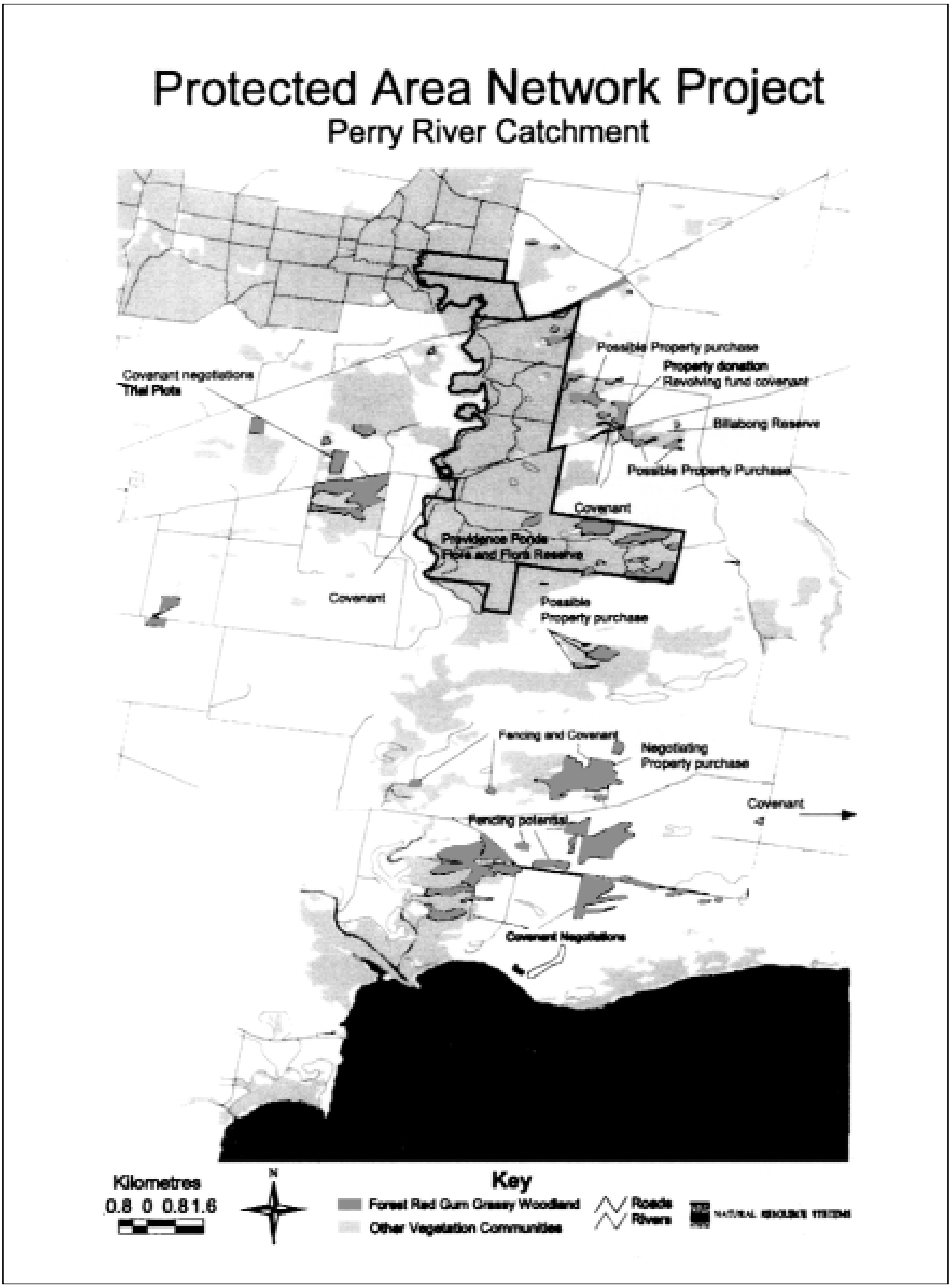
### Protected Area Networks

Addressing biodiversity protection in highly fragmented landscapes requires the development of a network of public reserves and private land managed in sympathy—a 'protected area network' (Prober & Thiele, this volume). Protected Area Networks (or 'conservation management networks') provide an effective answer to the problem of developing adequate reserve systems for highly fragmented communities (see Todd 1998; Ross 1999b).

A conservation reserve system that incorporates private management is likely to be more easily achieved and politically acceptable than an approach based on public acquisition alone (Howard & Young 1995). Whether a site is protected as public or private land will depend on a range of factors, including current land status, land values, threats, desired management, availability of incentives, willingness of landowners to negotiate, and many more. The Perry River Protected Area Network, being developed by the Trust for Nature in Gippsland, includes existing reserves, purchases, covenants, revolving fund acquisitions and fencing agreements (Fig. 1).

All protected areas should have site-specific management plans and agreements and overall management should be coordinated across the Protected Area Network by a single organisation (Binning & Young 1997).

Figure 1. Perry River Protected Area Network. A range of mechanisms is being used to secure conservation management for individual sites within this network of protected areas.



### Incentives

While there will be agricultural benefits in retaining native grassland, absolute management for nature conservation will almost always require some sacrifice in production or loss of future opportunities for individual landholders. These costs must be recognised if effective partnerships are to be developed. Failure to do so, especially by overstating or generalising the benefits of retaining native grasslands, risks alienating farmers and farm advisers.

The economics of grassland conservation on farms is such that more than education is needed to change behaviour. A major program of incentives will be required if the status quo is to be maintained, if not improved. Options for targeting incentives are discussed by Crosthwaite (1997a; 1997b; this volume). For properties that have native grasslands of high conservation significance, a targeted approach based on the circumstances of the whole farm is desirable. Incentives should be linked to structural change to achieve long-term farm viability and secure protection for native grassland.

Incentives aimed at the conservation site can also be successful where threats to the site are relatively low and the cost of conservation is manageable. In Gippsland, the offer by Trust for Nature (Victoria) of surveys and ongoing management advice coupled with fencing incentives and rate rebates has been effective in securing long-term protection for relatively low cost.

Elix and Lambert (1997) recommend the development of a 'toolkit' for private landholders that includes:

- practical information and advice on the significance and management of remnants;
- provision of incentives for integrated management that includes a strong conservation component;
- provision of fencing subsidies contingent on entering into management agreements; and
- development of a 'stewardship' scheme.

### Stewardship

The type, frequency and consistency of management, or lack of it, has a profound influence on the composition of grassland flora and fauna. Perhaps more than any other ecosystem type, the long-term conservation of native grassland communities and their constituent species are dependent on the maintenance of regular, high quality, strategic management.

Nowhere is the application of effective management more important than on newly acquired reserves. Sites that are reserved for conservation should be promoted as models for the protection and sustainable management of native grasslands. The adoption of a conservative approach based on existing management regimes and involving local landholder input are important steps in gaining the confidence and support of local communities.

Protection through management agreements or by reservation will not in itself ensure conservation. At present, grassland communities in all regions are undergoing a loss of diversity on private and public land due to poor or insufficient management. Areas protected under management agreements will still require a degree of management advice and assistance as well as regular inspection. Effective management agreements must both achieve and retain strong landholder commitment by developing a partnership with the landholder. This involves a genuine commitment from government (or other contracting organisations) to provide ongoing advice and resources.

Grassland management should focus on outcomes—achieving specified objectives by the best means possible. Lunt and Morgan (1998) have recommended the adoption of adaptive management principles for all native grasslands managed for conservation. They emphasise that learning from management outcomes should be a specific objective of conservation management and that management should be structured in such a way that assessment is possible. They argue that it will prove to be far more cost-efficient and effective to integrate research issues with management, rather than to maintain the two as separate activities.

## Best practice models

The Grasslands Stewards/Advisers Program of Trust for Nature (Victoria) provides the most complete model of how a grassland conservation program can operate. The program is based on the philosophy that long-term conservation on private land requires a change in property rights and effective management in perpetuity.

The key elements are:

- identify significant remnants through surveys, existing databases and personal contacts;
- establish one-to-one relationships with the owners/managers of those remnants;

- seek permanent change to tenure through covenants, purchases or other mechanisms;
- maintain the same extension workers for the period of the program;
- maintain extension programs for a minimum of three years;
- use non-government organisations rather than government agencies to build relationships with private landowners;
- use incentives to encourage and reward conservation;
- develop networks of protected areas on public and private land; and
- develop a stewardship fund to provide on-going support and advice for managers of protected areas.

## Conclusion

The relationships, trust and capacity in local and regional communities that are required for long-term conservation of native grasslands take time to build. Grassland programs must therefore be supported until these elements are in place.

It is clear from case studies that such long-term programs will be most effective where they are both comprehensive and strategic. Within these programs, effective extension projects that utilize a range of mechanisms for permanent or long-term protection of priority sites will be fundamental to success. And success, once achieved, should always be celebrated.

## Acknowledgements

This project was funded by the Commonwealth Government through the National Reserve System Program of the Natural Heritage Trust.

Many people generously gave of their time, expertise and opinions during the conduct of this project. I would especially like to thank Roberta Thorburn of Environment Australia, Tim Barlow of the Victorian National Parks Association, Jamie Pittock and Philippa Walsh of WWF for their support and assistance with the conduct of this project. Ian Lunt, Gillian Lee and Maria VanderGragt made many useful suggestions and comments on a draft report for this project and their thoughts have contributed greatly to this paper. Robyn Edwards provided the map of the Perry River Protected Area Network.

## References

ACT Government 1997. Natural temperate grassland: An endangered ecological community. Action Plan No. 1, Environment ACT, Canberra.

Barlow, T.J. 1996. The vegetation of twenty-five grassland and grassy woodland remnants on farms in south-western Victoria. Trust for Nature (Victoria).

Binning, C. & 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. Environment Australia.

Crosthwaite, J. 1997a. The Economic Benefits of Native Grassland on Farms. Environment Australia – Biodiversity Group. Grassland Ecology Program Project Number GEP 017.

Crosthwaite, J. 1997b. Native grassland: at what cost? Paper to the 41st Annual Conference of the Australian Agriculture and Resource Economics Society, Gold Coast 22-24 January 1997.

Diez, S. & Foreman, P. 1997. Remnant vegetation survey and botanical inventory of the Loddon Shire (part 2) (Former Shires of East Loddon, Korong and the former City of Marong). Unpublished report to Loddon Shire Council and the Dept of Natural Resources & Environment.

Elix, J. & Lambert, J. 1997. More than just the odd tree: Report on incentives and barriers to rural woodland conservation using Grassy White Box Woodlands as a model. National Research and Development Program on Rehabilitation, Management and Conservation of Remnant Vegetation, Research Report 1/98, Environment Australia.

Gilfedder, L. & Kirkpatrick, J.B. 1995. A survey of landholder attitudes and intentions towards the long-term conservation of native lowland grasslands. Report to the Australian Nature Conservation Agency. University of Tasmania, Hobart.

Howard, B. & Young, M. 1995. Selecting and costing a representative expansion of the NSW Protected Area Network. CSIRO Wildlife & Ecology Working Document, Canberra.

IUCN 1994. IUCN Red List Categories. IUCN, Gland.

Kirkpatrick, J.B. 1983. An iterative method for establishing priorities for the selection of nature reserves: an example from Tasmania. Biological Conservation 25: 127-34.

Lambeck, R.J. 1999. Landscape planning for biodiversity conservation in agricultural regions: a case study from the wheatbelt of Western Australia. Department of Environment and Heritage, Canberra.

Lunt, I. D. 1995. European Management of Remnant Grassy Forests and Woodlands in South-eastern Australia – Past Present and Future? Vic Nat 112 (6): 239-49.

Lunt, I.D., Foreman, P. & Wilson, B. 1999. Terrick Terrick National Park environmental information, assessment and mapping. Unpublished report to Parks Victoria, Melbourne.

Lunt, I.D. & Morgan, J.W. 1998. Second generation management of grassland reserves: lessons from first generation reserves. Report to Environment Australia and the Victorian Grassy Ecosystems Reference Group. La Trobe University, Melbourne.

Maher, P.N. & Baker-Gabb, D.J. 1993. Surveys and conservation of the Plains-wanderer in northern Victoria. Arthur Rylah Inst. Env. Res. Tech. Rep. No. 131. Department of Conservation and Natural Resources, Victoria.

McDougall, K. & Kirkpatrick, J. (eds) 1994. Conservation of Lowland Native Grasslands and Grassy Woodlands in South-eastern Australia. World Wide Fund for Nature, Sydney.

Muir, A. 1996. Significant Grassland and Grassy Woodland sites of the Victorian Volcanic, Coastal and Riverine Plains. Preliminary Report – Stage One. Dept of Natural Resources and Environment. A Report to the Australian Nature Conservation Agency. NRSCP Project no. N408.

NSW NPWS (in prep). Plains-wanderer: Draft Recovery Plan. National Parks and Wildlife Service, Sydney.

Owen, R. 1997. The native grasslands and grassy woodlands of Gippsland's Red Gum Plains. Trust for Nature (Victoria).

Pressey, R.L., Ferrier, S., Hutchinson, C.D., Siverston, D.P. & Manion, G. 1995. Planning for negotiation: using an interactive geographic information system to explore alternative protected area networks. In: D. A. Saunders, J. L. Craig & E. M. Matiske (eds) Nature Conservation 4: the role of networks. Surrey Beatty & Sons, Chipping Norton, NSW.

Prober, S. & Thiele, K. 1998. Establishment and management of the "Grassy White Box Woodlands Reserve". Final Report to Environment Australia, Canberra.

Prober, S. & Thiele, K. (in press). Reserve concepts and conceptual reserves: options for the protection of fragmented ecosystems. In: R. J. Hobbs & C. J. Yates (eds) Temperate Eucalypt Woodlands in Australia: Biology, Conservation, Management and Restoration. Surrey Beatty & Sons, Chipping Norton, NSW.

Robertson, P. 1999. Habitat assessment for five species of threatened vertebrates within the former Davies property at Terrick Terrick National Park. Unpublished report to Parks Victoria, Melbourne.

Ross, J.R. 1999a. Guide to Best Practice Conservation of Temperate Native Grasslands. World Wide Fund for Nature Australia, Sydney.

Ross, J.R. 1999b. Identification of priority areas for protection and establishment of protected areas: Victorian Volcanic Plain Bioregion. Unpublished Report to Parks, Flora and Fauna, Department of Natural Resources and Environment, Melbourne.

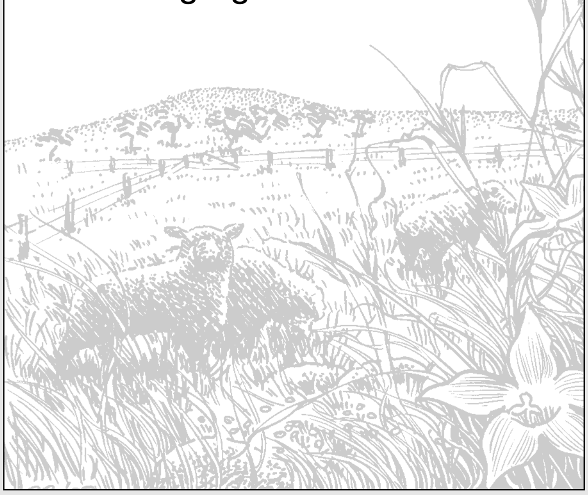
Sharp, S. & Shorthouse, D.J. 1996. Native grasslands and threatened species in the Australian Capital Territory: Steps towards protection and recovery. In: S. Stephens & S. Maxwell (eds) Back from the brink: refining the threatened species recovery process. Surrey Beatty & Sons, Chipping Norton, NSW.

Thackway, R. & Creswell, I.D. (eds) 1995. An Interim Biogeographic Regionalisation for Australia: a framework for setting priorities in the National Reserves System Cooperative Program. Australian Nature Conservation Agency, Canberra.

Todd, J.A. 1998. Identification of priority areas for protection and the establishment of protected area networks in the Riverina Bioregion Victoria. Unpublished Report to Parks, Flora and Fauna, Department of Natural Resources and Environment, Melbourne.

# Session 6

## Managing Native Pasture



# Balancing pasture development options for landscape diversity

Peter Simpson

NSW Agriculture
PO Box 389, Goulburn NSW 2580
peter.simpson@agric.nsw.gov.au

Rural landscapes in the high rainfall tablelands areas are multi purpose, should be non-polluting to other areas and can be managed to achieve one or more of the following: clean air; clean water; biological diversity; and agricultural production.

Variability of landscapes, pasture and climate provide challenges and rewards for sound whole farm planning. Long term profit from grazing enterprises is based on keeping the perennial grass component and maintaining species diversity. Recognising the strengths and weaknesses of the natural resource base is essential for long term successful integration of pasture development options. Alternative strategies are discussed in relation to key landscape features.

Current industry structure, age of rural operators, grazing industry cash flow and rural subdivision are all major socio-economic factors that are influencing the future direction of the grazing industry for the 21st Century.

While maintaining low input native pasture based systems may be environmentally attractive, the potential productivity from such systems is estimated to be $30 to $60 per ha lower in short term profitability than other higher input or replacement pasture development options. Unless some incentives are offered, it is unlikely that there will be broad industry acceptance for low input pasture systems or for redirecting or retiring land from grazing, e.g. for revegetation, conservation.

Keywords: balance, pasture, diversity

## Introduction

There is an incredible range of landscape and pasture diversity in the recharge higher altitude Tablelands areas of NSW. While this paper focuses on these areas, the management principles outlined will apply to a wider range of higher rainfall zones in NSW and north-eastern Victoria.

The diversity of soil type, aspect, topography and unpredictable and variable rainfall presents a major challenge and reward for recognising and managing permanent pastures in a predominantly grazing environment. Selection of pasture development methods and management options should be based on whole farm natural resources and long term profitability. Five factors have a major influence on the ultimate selection. These are:

- existing pasture composition and production;
- establishment reliability and costs;
- persistence, particularly of the perennial grass component;
- sustainability of increased stocking rates;
- gross margin return per dry sheep equivalent (DSE) and per hectare.

I believe there are two fundamental principles that must be recognised and appreciated for developing sustainable and profitable livestock enterprises on a whole farm basis. These are:

1. sustainability—the need to maintain perennial species and ground cover. This includes native perennial grasses, introduced or exotic perennial grasses and other vegetation based on native or introduced trees and shrubs.
2. profitability—maximum livestock performance will only be achieved when there is palatable green leaf on offer all year round (i.e. digestibilities are maintained above 65%).

Table 1. Carrying capacity by pasture type

| Pasture Type | Carrying capacity (DSE per ha*) | Range (DSE per ha) |
|---|---|---|
| Poor native pasture (e.g. Wire Grass, Spear Grass) | 1.0 | 0.5 to 2.5 |
| Good native pasture (e.g. Red Grass, Wallaby Grass, mixtures) | 2.5 | 2.0 to 3.5 |
| Native pasture plus subterranean clover/superphosphate | 5.0 to 10 | 3.0 to 14 |
| Sown perennial grass, clover and superphosphate | 7.5 to 15 | 5.0 to 25 |

* One DSE (dry sheep equivalent) equals one merino wether. One crossbred ewe equals two DSE. One breeding cow equals 15 DSE.

## Background

Table 1 lists the broad range of pasture types present on the NSW Tablelands and their broad carrying capacities.

The most significant thing to me is the wide range in carrying capacities for all pasture types, be they native pasture with or without subclover and a low input of fertiliser, or a sown pasture based on introduced species. I believe this is primarily a function of rainfall, soil type, aspect, topography, diversity of species present, and, last but not least, management, including owners attitude to risk.

Surveys carried out during the last decade reveal that many farmers only expect pastures based on introduced perennial grasses to persist for 5 to 10 years (Archer et al. 1993). This questions the economics of a replacement approach for pasture development with introduced species under current cash flow returns in these environments (Patterson 1995).

The interactions between soil fertility and rainfall have a powerful effect on the time required to recoup the development costs associated with sowing introduced pastures (Table 2).

However, if you look at the expected range of stocking rates for various pasture types in Table 1 and compare this to the internal rate of return estimated for agroforestry (3% to 7%), then on economics alone many grazing properties in recharge landscapes would yield a higher rate of return if planted with trees (Table 3). And this ignores any off-farm benefits (e.g. salinity amelioration, carbon credits, weed control, etc.).

Developing and adopting pasture management systems that are harmonious to the natural resource base is essential if we are ever going to be able to move towards the concept of sustainable agriculture. Agricultural policy in Australia is moving towards increasing global trade and encouraging a 'survival of the fittest' approach. There are winners and losers in this strategy, in human, economic and landscape terms.

Current industry structure, age of rural operators, grazing industry cash flow and rural sub-division are all major socio-economic factors that are influencing the future direction of the grazing industry for the 21st Century in the permanent pasture high rainfall recharge areas.

Most family farm adjustment occurs between rather than within generations, so that the cost price squeeze can have a strongly negative effect on the farm when an introduced pasture system cannot be maintained. On-farm and regional problems such as acidity, salinity, spread of noxious weeds, vegetation dieback and degraded pastures are

Table 2. Soil/rainfall influence on sown pasture cost recovery

| Rainfall/Soil Fertility | Years to Recover Costs | |
|---|---|---|
| | Arable areas | Non-arable areas |
| High[1] rainfall, high soil fertility | 5 | 6 |
| High[1] rainfall, low soil fertility | 8 | 9 |
| Low[2] rainfall, high soil fertility | 6 | 10 |
| Low[2] rainfall, low soil fertility | Never | Never |

[1] high rainfall = > 750 mm $yr^{-1}$

[2] low rainfall = < 500 mm $yr^{-1}$ (Source: Vere & Campbell 1983)

Table 3. Estimated long term return on capital at various stocking rates for a medium wool sheep enterprise with 90% equity

| Stocking rate (DSE/ha) | Land value $1250/ha | Land value $1400/ha |
|---|---|---|
| 10 | 1.8% | -0.3% |
| 11 | 4.5% | 2.2% |
| 12 | 5.7% | 4.3% |
| 15 | 7.6% | 6.2% |

(Based on 21 micron greasy wool selling for 700¢ per kg) (Source: Sykes 1998)

widespread and increasing. Farmers are well aware of the on-farm and off-farm benefits of maintaining perennial species and ground cover. The sad reality is that when you're battling for economic survival, short-term cash flow decisions dominate resource allocation (Fig.1). Solutions will have to be based on a partnership between urban consumers and rural producers, and this means an ongoing capital injection outside of farm cash flow and a serious review of tax and land laws.

## Managing native grass-based pastures

Simpson and Langford (1996) present a comprehensive summary of current knowledge and experience relating to native pasture management in the higher altitude recharge areas of the southern portion of the Murray Darling Basin. However, there are some critical knowledge gaps relating to:

- restoring degraded native pastures in non-arable areas where there has been loss of perennial species and/or ground cover;
- management to maintain species biodiversity, be it primarily for conservation or agriculture; and
- seedling recruitment and survival of the perennial grass components.

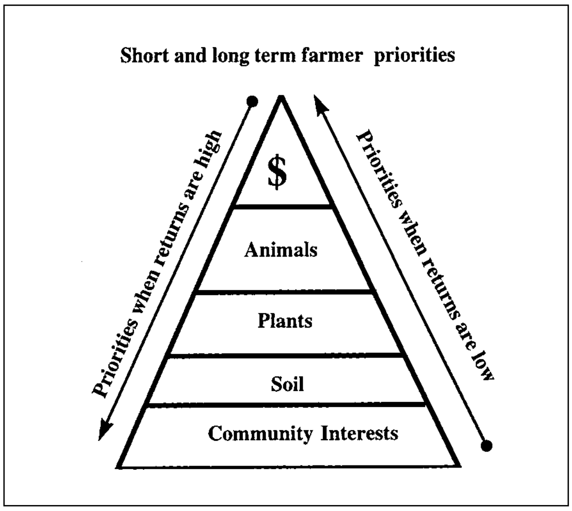
Native pasture occurs on a wide range of topography, aspect and soil types, in large paddocks where targeted grazing management is extremely difficult if not impossible to implement. Maintaining pasture species that match soil type and enterprise needs and provide ground cover as well as production is essential for sustainable profit. There is no perfect grass or legume: each has its own combination of strengths and weaknesses, and this diversity allows landholders choice when considering pasture development options that relate to the diversity of landscape features present. The following are some critical landscape or climate features that can be easily recognised and have an important influence on development and management options.

### Rainfall

In south-eastern Australia, rainfall ranges from 500 to 1500 mm, though the more critical components are rainfall variability, infiltration and evaporation. The most reliable period for the build-up of soil moisture is during winter when there is the least amount of pasture growth. We very much depend on converting millimetres of rainfall into pasture growth in a notoriously unreliable summer–autumn period or in the more reliable spring period.

It seems that most of our introduced species have incredible potential for growth in the spring, creating embarrassing surpluses of feed, but do very little to provide out-of-season green feed in the late spring/summer/early autumn period. Weaner nutrition is often a problem when summer active species are not part of the pasture.

Figure 1. Short and long-term farmer priorities (from Hutchinson 1991)



The interaction of rainfall with aspect has a major effect on the length of the growing season and pasture maturation in spring, with exposed western slopes having major limitations. The true effect of rainfall is reflected in the length of the pasture growing season, which is also related to the diversity of species present, across the range of landscapes, that can respond to and utilise rainfall whenever it falls.

### Soils

There is a great variation in soil type on the Central and Southern Tablelands of NSW (Hird 1991). Generally, the arable non-stony basalt areas where rainfall is in excess of 500 mm are well suited to high input pasture systems based on introduced species. Acidity problems are low to minimal and these soils are fertile and have high rainfall infiltration rates. Unfortunately, less than 5% of the Central and Southern Tablelands is based on basalt soils. There is a large proportion of granite soil (about 30%), of substantially lower fertility than basalt soils. Granite soils are rarely naturally strongly acid and, while some areas are highly erodible, they can be improved satisfactorily by sowing introduced species. Granite soils tend to become more acid over time with pasture improvement and, in some areas, dryland salinity is occurring on the lower slopes and in discharge areas.

By far the most challenging and diverse soils are those of a sedimentary duplex nature (over 50% of the total area). Many of these soils are naturally acid (pH below 4.5 in $CaCl_2$) and are located in semi-arable to non-arable environments. Frequently, these soils have acidity extending to a depth of 1m or more.

These areas can be easily identified by the native timber and pasture species present. Peppermints (Eucalyptus dives and E. radiata), White Gum (E. rossii), She-oak (Allocasuarina spp.), Ironbark (E. crebra) and Sifton bush (Cassinia spp.) nearly always indicate strongly acid soils. Wiregrass (Arisida ramosa), Weeping Grass (Microlaena stipoides) and some Wallaby Grasses (Austrodanthonia spp) are also acid tolerant, and where they dominate it is likely soil will be acidic (Simpson 1994). Kangaroo Grass (Themeda triandra) and Red-leg Grass (Bothriochloa macra) tend not to grow in strongly acid soils and are usually associated with Yellow Box (E. melliodora), White Box (E. albens) or Apple Box (E. bridgesiana).

If acidity is only present in the surface 0 to 15 cm, then applications of lime can correct this problem. Major limitations to pasture intensification occur where acidity occurs to below 15 cm, since liming is relatively ineffective and doubtful economically given the rates required. Pastures based on acid tolerant species are the only option, and where perennial and acid tolerant native grasses are present (e.g. Microlaena and Austrodanthonia) non-destructive development options are preferred (Simpson 1994).

### Slope & Erodibility

Less than 10% of the high rainfall tableland areas are arable (i.e. where the risk of erosion from cultivation is minimal and cropping is therefore an option). The balance is characterised by soil types that include highly erodible granites and sedimentary duplex soils, where cultivation can pose a high erosion risk particularly when carried out over summer-autumn when high intensity storms are likely. In these erodible environments, pasture establishment options are limited to surface sowing and/or direct drilling.

The rankings of pasture types in Table 4 relating to slope have been strongly influenced by the need to retain ground cover and, consequently, reduce erosion risk. Pasture persistence and the maintenance of ground cover should be the prime focus when considering development options on the steeper, more erodible acid soils. It is futile to destroy existing stands of native perennial grasses when they cannot be replaced by a pasture mixture of equivalent persistence.

Some areas of steep, erodible acid soils may be best not developed at all, but lightly grazed and/or revegetated. Where further degradation problems exist (e.g. noxious weeds), perhaps timber will be the most sustainable and economic enterprise in the long term, be it for weed control, harvesting of clean water, salinity reduction, long term income from wood or carbon credits (when and if they eventuate) (Simpson 1998). See Figure 2 for details.

### Land Class

The wise manager knows the features of their natural resource base, particularly features they can modify, and those they can't (e.g. subsoil acidity, aspect, slope). Selecting and/or maintaining those species that match the soil type and enterprise needs, and also provide ground cover, is essential for long term sustainable profit from pastures.

Various organisations have different methods for classifying land capability, although they all attempt

Table 4. Interactions between pasture type, soil factors and long term pasture productivity

| Pasture Type | Suitability to Slope[1] | | | Suitability to Soil Acidity[2] | | Suitability to Soil Fertility | |
|---|---|---|---|---|---|---|---|
| | Flat[3] | Undulating[4] | Steep[5] | Low | High | Low | High |
| Native (no fertiliser or legumes) Summer growing (e.g. *Themeda*, *Bothriochloa*, *Microlaena*) | * | ** | ***** | * | ***** | *** | * |
| Native pasture plus legumes/ fertiliser (summer growing) | ** | *** | **** | ** | *** | **** | ** |
| Native pasture plus legumes/ fertiliser (year long green natives, e.g. *Austrodanthonia*, *Microlaena*) | ** | **** | ***** | *** | ***** | ***** | **** |
| Degraded introduced pasture dominated by annual grasses and broadleaf weeds. | ** | ** | * | ** | * | ** | ** |
| Introduced pasture with perennial grass plus fertiliser and legumes | ***** | **** | ** | ***** | ** | **** | ***** |

Note: More *** indicates better performance over time.

1 Related to persistence and production of perennial pasture, ground cover and steepness of land.

2 Acidity: Low (pH - above 5.0 CaCl2 test). High (pH - below 4.5 both top and sub soil. Aluminium above 15% Cation Exchange Capacity).

3 Arable.

4 Arable by direct drilling.

5 Can only be improved by aerial means.

to rank the ability of the natural resource base to sustain production. High input/high output systems with current technology options are best suited to Class 1 and 2 country for both pastures and crops. Increasingly, as you move into Class 3 country, the balance between agricultural productivity and conservation goals becomes more important and difficult to achieve. If Australian Phalaris cannot be reliably established and managed as the basis of the sown pasture, then other introduced perennial grasses have to be used (e.g. Ryegrass, Fescue, Cocksfoot), but are unlikely to persist for longer than 10 years in many environments. The major focus in Class 4 and steeper country is to maintain ground cover. Development and management strategies could consider encouraging the year-long green, grazing tolerant native perennial grasses if present.

The most economically and agriculturally sustainable method for increasing the productivity of native grass pastures in non-arable hill country will be by non-destructive pasture development and management, i.e. low input fertiliser use plus oversowing with an annual legume. This strategy is essential if the soil is acid (pH below 4.5 $CaCl_2$).

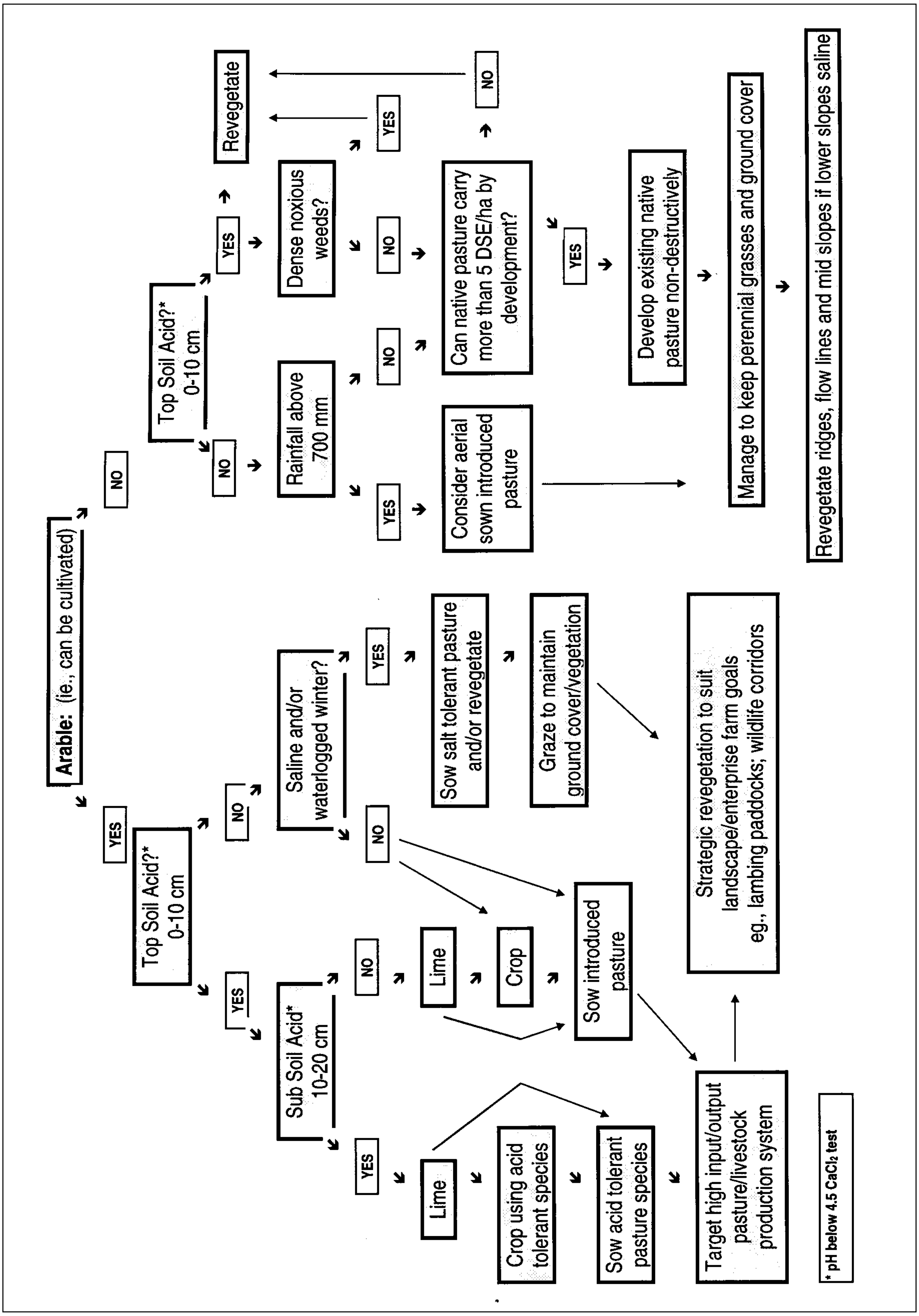
The aim is to modify the existing pasture diversity slowly, encouraging the oversown annual legume component (but avoiding clover dominance) over a five to ten year period, aiming for an ultimate carrying capacity somewhere between five to 12 DSE/ha.

An alternative management option is no inputs apart from seasonal grazing or fire to maintain ground cover and/or existing pasture diversity (i.e. conservation goals are a high priority).

## Noxious Plants

The most invasive and widespread noxious plant in the region is Serrated Tussock (Nassella trichotoma). In non-arable areas on low fertility acid soils, pasture management must be based on 'keeping clean country clean'. This is a real challenge, but if not pursued, Serrated Tussock will ultimately dominate all pasture types, and revegetation may be the only feasible option (Roberts 1996).

Figure 2. Influence of major landscape features on development options



## Balancing pasture type and landscape

There are five major factors that determine whether native, modified native, or introduced perennial grass-based pastures are likely to best fit the landscape. These are: land class, slope/erodibility, soil acidity, aspect and drought persistence. Table 4 compares various pasture types in relation to these factors, and Table 5 outlines the tolerance of individual pasture species to drought, acidity and grazing, their herbage value (based on palatability and green leaf biomass) and their response to fertility (Simpson & Langford 1996).

## Summary

Sustainability of permanent pastures is directly linked to maintaining the perennial grass component and maintaining ground cover. Trying to associate short term productivity (e.g. stocking rate per hectare or short term enterprise gross margins) to disguise and prolong the need for industry structural reform is naïve and ignores the need for a whole farm approach that is in harmony with the natural resource base. This latter approach should be compatible with the broad aims of catchment management.

It is desirable that development and management strategies ensure that all areas of a property are used in the most cost-effective and ecologically sustainable manner. There are five broad pasture development strategies that can be applied to different areas:

1. high input/ high output replacement pasture systems based solely on introduced pasture species (e.g. Phalaris, Ryegrass, Cocksfoot, Fescue, clovers) and intensive fertiliser and livestock management;
2. degraded pastures based on introduced species plus weeds, with low fertiliser and stock management inputs;
3. low input systems with lower production potential, based on maintaining native perennial grasses (e.g. Austrodanthonia, Microlaena, Poa, Stipa, Bothriochloa) in association with introduced annual legumes and limited fertiliser applications;
4. maintaining a pasture primarily consisting of native perennial grasses (e.g. Bothriochloa, Microlaena, Themeda, Austrodanthonia) with no fertiliser or legume input;
5. using commercial native grass seed (when available) to modify or redevelop pastures. For example, replacing Wire Grass or annuals with year long, green native grasses (e.g. Microlaena, Danthonia).

Table 5. Major features of some common perennial grasses

| | Common Name | Botanical Name | Drought Persistence | Acid Soil Tolerance | Grazing Response | Herbage Value (**) | Fertility Response |
|---|---|---|---|---|---|---|---|
| Summer Growing | | | | | | | |
| * | Kangaroo Grass | *Themeda triandra* | H | L-M | L | L-M | L |
| * | Red-leg Grass | *Bothriochloa macra* | H | L-M | H | M | M |
| * | Wire Grass | *Aristida ramosa* | H | H | L | L | L |
| Yearlong Green | | | | | | | |
| * | Wallaby Grass or White Top | *Austrodanthonia* spp. | H | H | H | M-H | M-H |
| * | Weeping Grass | *Microlaena stipoides* | H | H | H | M-H | H |
| * | Tussocky Poa | *Poa* spp. | M-H | M-H | M-H | L-M | M-H |
| * | Spear Grass | *Stipa* spp. | M-H | M-H | M-H | L-M | L-M |
| Introduced | | | | | | | |
| = | Phalaris | *Phalaris aquatica* | H | L | H | H | H |
| = | Cocksfoot | *Dactylis glomerata* | M | H | H | M-H | M |
| = | Perennial Ryegrass | *Lolium perenne* | L-M | M-H | H | H | H |
| = | Fescue | *Festuca arundinacea* | M | H | M-H | M-H | H |

* Native
= Introduced (Rankings will vary according to variety and location.)
(**) Herbage value based on green leaf

All of these approaches have strengths and weaknesses from an agronomic, livestock, economic and conservation viewpoint. However, most tableland farms have a diversity of soil types, aspect, pasture types and enterprise needs, which enables a wide range of pasture and livestock management options to be utilised.

Development and management decisions in individual paddocks should not be made in isolation. Whole farm planning needs to consider all the factors as a total package and requires management for sustained profitability.

Survey work on the Central and Southern Tablelands has shown that many pastures classified as 'improved' have a significant component of native grasses contributing to the productivity of the pasture (Munnich *et al.* 1991; Garden *et al.* 1993). Munnich's survey showed that native pastures with a history of 'sub and super' were carrying, on average, 80% of the stocking rate (7 DSE/ha versus 9 DSE/ha) of a sown pasture based on introduced grasses. These native grass based pastures were, on average, located on soils nearly 10 times more acid than the introduced pastures (pH 4.1 versus 4.9 $CaCl_2$ test) and had only received one third of the fertiliser inputs. Agriculturally, the following points need to be considered when comparing different pastures:

- ability to provide herbage of a quality that satisfies livestock requirements throughout the year;
- suitability to soil type (acidity, fertility, drainage, etc.); and
- persistence for ground cover, erosion control and profit.

## Looking to the future

Trying to manage landscape and climate diversity is challenging. The limited opportunities for enterprise diversification away from grazing means that, for most situations, we have to make better use of what we've got, linked to the realities of cash flow and long-term pasture stability (PROGRAZE and Farming For The Future are two programs with this aim).

Whatever we do in agriculture based on grazing with sheep and cattle, the landscape will be modified over time. In any ecological processes, there are winners and losers. It then becomes a matter of judgement as to how to manage different pasture environments for production and biodiversity objectives. However, all user groups in society have to recognise that change is inevitable if current living standards are to be maintained.

Longer term whole farm and catchment management issues (harvesting clean water, salinity, acidity, pasture degradation, noxious weed invasion, etc.) are not going to go away. While some of these issues can potentially be solved, others are beyond the resources and cash flow of many landholders.

Retiring land from grazing, adopting low input/low output pasture management strategies, revegetation programs, and topdressing lime on acid tolerant pastures to maintain ground cover are all current options. However, I can't see their widespread adoption given the current industry structure, operator age and cash flow.

It seems to me that biodiversity means different things to different people and that the key players in the landscape are the current landholders who are struggling to survive. Agricultural inputs in predominantly native pasture environments will change the biodiversity, and there will be winners and losers. This is particularly true under grazing, and the gross margin income forgone will range from $30 to $60 per hectare, depending on the landscape and management system involved (see Table 1). I have no doubt that some of these strategies are appropriate for the non arable acid soil hilly areas, where maintenance of perennial ground cover is paramount, but who will fund the income foregone or what incentives or cost sharing arrangements are to be put in place?

Rural landscapes in high rainfall recharge areas are multi purpose. They should be non-polluting and managed to produce clean air, water, biological diversity and agricultural production. Integrated policy and programs based on cost sharing or incentive schemes must be developed and implemented if we are to move forward into the 21st century (Crosthwaite & Malcolm 1999).

Landscape and climate diversity must be better understood, and management strategies implemented to maintain permanent ground cover and species diversity that is in harmony with the natural resource base (Young 1998; Johnston *et al.* 1999; Simpson 1999a, 1999b).

Many years ago at the end of a pasture field day down south, I was yarning with a producer who made the following comment – '*You know, life is a curious thing. It seems that I spend about half my time killing plants that germinate, grow, multiply and successfully persist or regenerate, and the other half trying to replace them with plants that won't*'.

I have been pondering the impact of this statement for a long time. It should make us all reflect on the cause and effect over time of what we are doing, where we are going, and where we would like to be with our landscapes in the 21st Century—a challenge to us all!

## Acknowledgements

I acknowledge and appreciate the constructive comments by Denys Garden and Peter Orchard in the preparation of this paper.

## References

Archer, K., Read, J., Murray, G. 1993. Pasture decline – real or imagined? *Proceedings 8th Annual Conference, Grassland Society of NSW*, pp. 8-13.

Crosthwaite, J. & Malcolm, W. 1999. *An economic analysis of native pasture in the hills and tablelands of south-eastern Australia.* Institute of Land and Food Resources, University of Melbourne.

Garden, D.L., Dowling, P.M. & Simpson, P.C. 1993. Native grass management for sustainable agriculture. Final report to Murray-Darling Basin, National Resources Management Strategy. Project N24. NSW Agriculture.

Hutchinson, K.J. 1991. Sustainable grazing systems – an overview. Sheep & Wool Seminar, Tamworth. NSW Agriculture, pp. 1-11.

Johnston, W.H., Clifton, C.A., Cole, I.A., Koen, T.B., Mitchell, M.L. & Waterhouse, D.B. 1999. Low Input Grasses in Limiting Environments (LIGULE). *Australian Journal of Agricultural Research* 50: 29-53.

Munnich, D.J., Simpson, P.C., Nichol, H.I. 1991. A survey of native grasses in the Goulburn district and the factors influencing their abundance. *Rangeland Journal* 3: 118-29.

Patterson, A. 1995. Profitable pasture establishment. *Proceedings of Victorian Grassland Society, Annual Conference*, pp. 41-52.

Roberts, C.D. 1996. The role of *Pinus radiata* as a tool in the control of serrated tussock. State Forests paper for Serrated Tussock Workshop, Goulburn. NSW Agriculture.

Simpson, P.C. 1994. Perennial native grasses – acid soil tolerance. Landcare in the Balance. In: C.H. Bastick, D.N. Wright & N.J. Mendham (eds) *Proceedings of the 1994 Australian Landcare Conference*, Hobart.

Simpson, P.C. & Langford, C.M. 1996. *Managing High Rainfall Native Pastures on a Whole Farm Basis.* NSW Agriculture.

Simpson, P.C. 1998. Trees and pastures – finding a balance. Regional paper for Greening Australia, Bushcare Seminar, Goulburn. Greening Australia.

Simpson, P.C. 1999a. Recognising and managing landscape and pasture diversity. *Proceedings of NSW Grasslands Society 14th Annual Conference*, pp. 18-24.

Simpson, P.C. 1999b. Pasture management for production and catchment biodiversity – aims of pasture management. Regional Workshop, Friends of Grasslands, Canberra.

Sykes, J. 1998. Economic comparisons between sheep and softwood enteprises. Notes for Trees on Farms field days. Murray Development Commission, Albury.

Vere, D.T. & Campbell, M.H. 1983. Economics of Serrated Tussock control. NSW Agriculture, *Agfact* 87.M.1.

Young, M.D. 1998. Conditions that will make Australia exemplary. National Acidification Conference, Glen Osmond, SA.

# Perennial native grasses – the quiet achievers

W. H. (Bill) Johnston

NSW Department of Land and Water Conservation,
Centre for Natural Resources Research Centre
PO Box 5336, Wagga Wagga NSW 2650
wjohnston@dlwc.nsw.gov.au

Throughout southern Australia, clearing, cultivation and grazing have irreversibly altered landscapes. In grazed grasslands, tall, summer-growing species have generally been displaced by short, winter growing species, indigenous species by introduced plants, and perennials have been displaced by annual species. Annual water use has declined, groundcover is often below the thresholds needed to prevent soil erosion, and the nitrogen cycle has become truncated.

The movement of water beyond the reach of plant roots in autumn and winter mobilises salt stored in the landscape, leading to saline discharge. Intense runoff events and low groundcover leads to soil erosion and the loss of nutrients in runoff, while nitrate leaching is a major contributor to soil acidification. These processes are recognised as major barriers to agricultural sustainability.

The role of native perennial grasses in maintaining catchment health has been largely ignored and upper catchments have typically become the most degraded and mismanaged parts of the landscape. Nevertheless, native perennial grasses are adapted to harsh sites, variable climates and soils that are typically shallow, acid, stony and infertile.

The key to maintaining native perennial grasses on hilly landscapes and achieving a balance between productivity and sustainability is to minimise the effect of competition in spring by annual plants, and opportunities for selective grazing during the rest of the year. Grazing by low livestock numbers for long periods of time is particularly detrimental. Grazing management that encourages recruitment and minimises over-grazing of preferred species may reverse degradation trends for grasslands that still contain indigenous perennial species.

## Introduction

The 1.06 Mkm$^2$ Murray-Darling Basin (MDB) in south-eastern Australia is a complex mix of resources, people, culture, landscapes, production systems and heritage. Over 90%[1] of the Basin is under some form of agricultural landuse, mainly grazing (86%). The Basin contains almost half (42%) of Australia's farms and one-quarter of its dairy farms. It supports about 25% of Australia's cattle, about 45% of the Nation's sheep, lambs and cropland and about 50% of Australia's pigs. About 45% of the total tonnage of cereal crops grown in Australia come from the MDB. The Basin also contains almost 75% of Australia's irrigated land and it produces 83% of Australia's grapes.

The MDB is a diverse agricultural factory bounded by the highest points of the Great Dividing Range in the east, where the rainfall is high and reliable, and weathered low-profile ranges in the west, where rainfall is low and intermittent. It extends over about 10° of latitude from central Queensland to South Australia.

Despite its importance as a drainage basin, some 86% of the land area of the MDB contributes virtually no runoff to the rivers except during floods. Even in the high-rainfall areas in the south-east, where annual rainfall may exceed 800 mm, runoff yield is less than 125 mm/year (10 to 15% of the rainfall). About 46% of the runoff that does occur in the Basin is contributed by only 3 rivers—the Upper Murray, Murrumbidgee and Goulburn Rivers, which rise in the NSW and Victorian high country.

1 Statistics for this section were obtained from Crabb (1997).

Runoff is a small component of the overall water balance of the MDB. Most of the rainfall is accounted for by evapotranspiration (from plants and soil). Deep drainage (water draining away through the soil or bedrock and ending up in watertables) is also a small water balance component in natural woodlands and grasslands. Taken over the landscape, the balance between runoff, water loss to the atmosphere, and deep drainage to water tables is maintained entirely by perennial plants. It is a balance that is easily disturbed.

This paper examines the role of native perennial grasses in maintaining the health of small (less than 100 $km^2$) catchments that occur in the 500 to 700 mm rainfall zone along the western fall of the Great Dividing Range in southern Australia. Changes in the hydrological characteristics of these catchments in response to agricultural development are outlined. Steeper parts of these catchments have shallow, stony, erosion-prone soils, which are generally infertile and acid (pH $< 4.6$) to depth. They are also more arid and exposed than less-steep landscape classes. These hilly landscapes have a disproportionate impact on catchment condition and, therefore, need to be managed with care.

## The importance of hill lands

In a landscape sense, hill lands, valley floors and the extensive plains that stretch westward from the footslopes of the Great Dividing Range in south-eastern Australia are inseparable. Although they present quite different landuse opportunities, they are linked by processes such as runoff, siltation and watertable movements. In the MDB, hill lands are typically grazing lands, footslopes that can be cultivated are likely to be cropped or sown to improved pasture, and the low slope valley floors and plains are suited to cropping and irrigation.

In southern Australia, hill lands along the western fall of the Divide are the source of water for the high-value agricultural production in the MDB. Because of their position, they largely determine catchment condition in terms of water quality-turbidity, salt and phosphorous, and other habitat values. Changes in the condition of hill lands, and changes in their hydrology, have river-basin wide implications. However, despite their importance, surveys have shown that most hill land pastures are degraded (Kemp & Dowling 1991; Munnich *et al.* 1991; Allan *et al.* 1995) and most river catchments are deteriorating (Anon. 1989; Blackmore & Connell 1997; Crabb 1997).

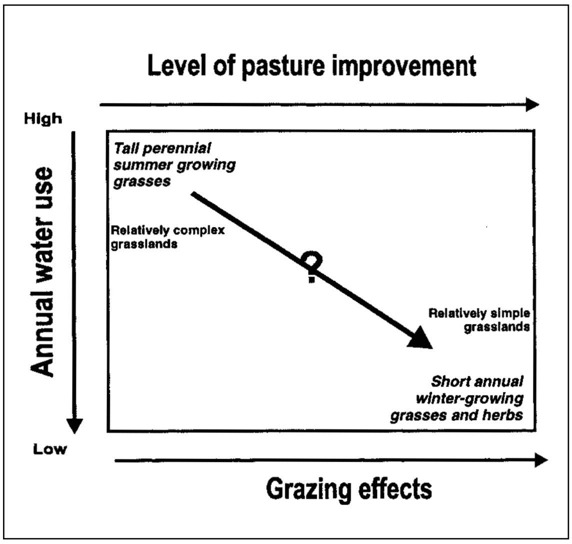
## Clearing- cause and effects

The most far-reaching impact of European settlement on the MDB has been due to clearing and the deliberate or accidental replacement of the original vegetation by fertility-responsive non-indigenous plants. In the southern part of the Basin, some 90% of the once-wooded wheat-sheep zone has been cleared and replaced by pastures and crops, and only about 25% of the original vegetation of the steeper grazing lands (tablelands and near-slopes) remains (MDBMC 1987).

Table 1. The frequency of $C_3$ and $C_4$ grass species in the flora of a number of ecological zones in south-eastern Australia, as reported by Hattersley (1983). (Note that the majority of species that have become naturalised are $C_3$ species (data in parenthesis).)

| Zone | Native species only | | | Native + naturalised species | | |
|---|---|---|---|---|---|---|
| | $C_4$ | $C_3$ | $\%C_4$ | $C_4$ | $C_3$ | $\%C_4$ |
| NSW Central T'lands | 37 | 80 | 32 | 58 (+21) | 132 (+52) | 31 |
| NSW Southern T'lands | 26 | 121 | 18 | 47 (+21) | 193 (+72) | 20 |
| NSW SW slopes | 37 | 45 | 45 | 63 (+26) | 107 (+62) | 37 |
| NSW SW plains | 66 | 46 | 59 | 93 (+27) | 86 (+40) | 52 |
| Central Victoria | 27 | 42 | 39 | 47 (+20) | 95 (+53) | 33 |
| SA Flinders Ranges | 57 | 29 | 66 | 62 (+5) | 59 (+30) | 51 |
| SA Northern Lofty R. | 23 | 23 | 50 | 26 (+3) | 58 (+35) | 31 |
| SA South-east | 20 | 54 | 27 | 35 (+15) | 116 (+62) | 23 |
| Tasmania | 15 | 107 | 12 | 34 (+19) | 190 (+83) | 15 |
| Australia as a whole | 540 | 289 | 64 | 676 (+136) | 445 (+156) | 60 |

Figure 1. A schematic representation of the changes induced in grasslands in southern Australia as a result of clearing and agricultural development




Clearing of trees is often believed to be the single greatest cause of the changes that have occurred in catchment hydrology. However, except for the Southern Tablelands of NSW and the uplands of north-eastern Victoria and in Tasmania, summer active $C_4$ grasses were also once prominent in the grasslands of southern Australia (Hattersley 1983) (Table 1). As illustrated in Figure 1, clearing, the introduction and invasion by exotic species, and application of fertiliser and grazing has switched species composition of the grasslands in favour of $C_3$ species and annual plants (Moore 1953, 1959,1965; Whalley *et al*. 1978). This also has far-reaching implications.

The extent to which grasslands have altered depends on the intensity and duration of the modifying influences. Undeveloped parcels of land such as cemeteries, nature reserves and railway easements have maintained their diversity and are regarded as valuable botanic refuges. At the other extreme, the composition of cropped land, heavily pasture-improved grazed paddocks, and areas where livestock congregate in camps or around trees and watering points, often contain only annual species and herbaceous weeds (Fig. 2). Most grazed grasslands today lie somewhere between these two extremes.

The effect of grazing on mixed grasslands has most often been ascribed simply to trampling and defoliation. However, as indicated by the question mark '?' in Figure 1, the processes are likely to be much more complex (Johnston 1996; Johnston *et al.* 1999). The impact of competition from invading plants; changes is soil nutrient and seasonal moisture status; access to space for recruitment; access to light for photosynthesis; and allelopathic effects have not been widely studied. Nevertheless, these effects are likely to impact more broadly on species dynamics than the simple impact of grazing.

Pasture improvement in southern Australia is synonymous with applying superphosphate and sowing Subterranean Clover to overcome the agronomic limitations of phosphorous and nitrogen deficient soils. Fertility-responsive $C_3$ grasses and herbs enjoy a strategic advantage as grassland invaders and they have become widely dispersed. $C_3$ species germinate as soils wet up in autumn and competition from summer-growing species declines. For pastures grazed over summer, there is usually a high proportion of bare ground at this time and available nitrogen levels are also high (Simpson 1987). $C_3$ annuals tolerate shade, germinate quickly, and rapidly deploy their leaf area.

Annuals provide high ground cover in spring, which denies recruitment opportunities to species that set seed the previous summer and that need increasing soil temperature and freedom from competition for germination and establishment. They are copious seeders and they set seed and senesce as evaporation rates increase, so they rapidly deplete soil moisture reserves in spring. This disadvantages perennial species that depend on stored soil moisture for growth and seed-set early in summer. Only summer active perennial species that are well-adapted to aridity, or summer-dormant perennials that do not need access to a large volume of stored

Figure 2. Areas where livestock congregate, such as the camp in the corner of this paddock near Cowra NSW, accumulate nutrients and over time become invaded by annual growing grasses and broadleaved weeds such as Patterson's Curse and Capeweed.

soil water, persist well. In contrast, $C_3$ perennial plants that commence growth in autumn and that are competitive with the annual species would be advantaged relative to $C_4$ species.

Change may be slow, but it seems inevitable. Droughts and wet years come and go, grazing pressure rarely remains constant, fertiliser is applied (or withheld), the dominance of groups of annual species oscillate, and new species arrive and invade. Simple cause/effect models fail to recognise the complexity of the processes involved and that they are potentially on-going. They do not provide insights as to how processes may be disrupted, re-directed, or utilised, so that grasslands may be used without degrading them, or degraded grassland may be managed so they repair themselves.

## Grasslands and the water balance

The water balance describes the fate of rainfall over the landscape. It is expressed as an equation such as:

*Rainfall = interception + change in soil water content + runoff and lateral flow + deep drainage + evaporation*

### Interception

Interception is that proportion of the rainfall that is directly evaporated from foliage and surfaces. It is an often-forgotten component of the water balance. It accounts for some 10-20% of the rainfall in uncleared forest and woodland and only some 1 to 10% in grassland and pasture. Clearing results in a reduction in interception that must be matched by equivalent increases in annual water use, runoff or deep drainage (or all three).

### Changes in soil moisture content

In much of south-eastern Australia, soils reach saturation during winter because, in most years, more rain is received than can be evaporated by the atmosphere. During the warmer months soils reach the limit of their dryness. These two points on the soil moisture availability curve define the available water capacity of a soil. However the limits themselves are determined by a range of soil physical characteristics, including soil texture, density, porosity, and stoniness. Deep friable soils may have an available water capacity of 100 to 200 mm, while shallow, stony soils may only hold 50 mm. When soils are saturated, any additional rainfall must appear in the water balance as runoff and lateral flow or deep drainage.

### Runoff and lateral flow

Landscape elements do not receive equal amounts of effective rainfall (that is, rainfall that soaks into the soil and remains there for plants to use). Water redistributes naturally and this is a factor in why plant communities occupy different habitats (Johns 1981; Birch *et al.* 1987). Soils with low infiltration rates shed more rainfall than more porous soils. Shallow, stony soils, or eroded soils where most of the topsoil has been lost, hold less water in their root-zone so must contribute more to runoff and deep drainage. Such soils reach field capacity earlier in winter and dry out more quickly in summer than deep, friable, medium-textured soils typical of low–slope lands. Other features such as impermeable soil layers, steepness, inclination of the underlying bedrock, subsoil hydraulic properties and ground cover determine how rainfall is partitioned between runoff and lateral flow, and how much is lost by deep drainage.

### Deep drainage

Porosity and the existence of continuous pathways for drainage affect how freely water moves down the soil profile beyond the reach of plant roots. Sandy soils may drain freely, however the permeability of heavy clay subsoil horizons is usually low—1 to 2 mm/day. Soils of low permeability may still drain considerable volumes of water if their subsoil remains waterlogged for long periods.

The water balance would predict that runoff and deep drainage would be greater for the shallow, stony soils typical of catchment uplands, compared to deep friable soils. It would also predict that any reductions in water use, if not matched by an equivalent increase in runoff, must appear as increased deep drainage.

Increased deep drainage mobilises salts stored in the landscape and leads to rises in watertable levels. In the south-eastern sector of the MDB, watertables are rising at rates equivalent to between 4 to 10% of the annual rainfall. Salinity is now a major sustainability issue, and in the eastern States some 6.6 million ha are considered to be land at risk.

### Water use by plant communities - evapotranspiration

Changes in the amount of moisture held in soil through the year depends on rainfall and atmospheric demand on the one hand, and the extent to which plant roots penetrate and explore the soil mass, and the amount of green leaf present on the other. Green leaf provides the link between moisture in the soil and the drying power of the atmosphere, while root density and depth determines the ability of plants to utilise available water resources, and hence how much soil they can dry out. Annual plants that only grow through the cooler months do not require a strongly developed root system as they are able to grow on current rainfall and have less of a need to access stored water except in dry years. Thus their surface root systems are well developed. $C_3$ plants that grow into summer, and water-spending species (e.g. Lucerne), have more strongly developed taproot based root systems.

If there is no green leaf in pasture in summer, water will only be lost by direct evaporation and soils will dry only slowly at depths below 10-20 cm. Green leaf is also needed in winter, but water loss is restricted by low evaporation potential. The only time of the year when soils can really dry out is over summer. This requires plants with an ability to photosynthesise while minimising water loss, and to withstand high light intensity. These are some of the adaptive features of $C_4$ photosynthesis (Johnston 1996).

In their pre-European state, the wooded grassland communities of southern Australia maintained a capacity for year-long transpiration (Specht 1972). $C_4$ species, common in dry, light-saturated habitats, owe their success to a variety of water saving strategies coupled with efficient water use and tolerance of water stress. Perennial $C_3$ species prefer shaded, moist habitats or heavy soil types. They achieve high growth rates when they are actively growing by spending water rapidly (i.e. they are relatively inefficient); they depend on root penetration and moisture acquisition to supply their water requirements and rely on dormancy to escape periods when their moisture supply is exhausted.

Plant communities have many strategies for minimising competition and, except in extremely dry or cold habitats, the complimentary photosynthetic pathways of $C_3$ and $C_4$ plants allow them to co-exist. In natural woodlands, grasses often form a mosaic according to patterns of shade. A low rate of water use in spring extends the growing season for warm-season plants into summer, which allows them to set seed. Transpiration during summer dries the soil to the limit of its capacity and it is this pre-winter soil moisture deficit that controls the amount of rainfall the soil can take up in autumn and winter before it becomes saturated.

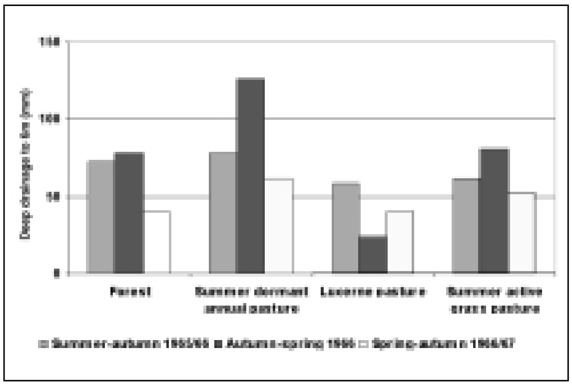
### Changes in the water balance induced by changes in pastures

Before the land was settled and developed for agriculture, trees and grasses together maintained the water balance across the MDB. As summer-active grasslands became invaded or replaced by cool-season plants, water use in spring and early summer increased at the expense of water use in late summer and autumn. This is the reverse of the pre-European water balance. Incomplete water use in summer reduced the amount of winter rainfall the soil can take up. Along the eastern uplands of the Basin, this has lead to increased rates of runoff or recharge (or both).

For pastures to mimic the water balance of pre-European plant communities, they must maintain a capacity for transpiration in summer and early autumn. This is unlikely to be achieved by $C_3$ perennial grasses, even those that remain green over summer. Water use by native species such as *Austradanthonia*, *Stipa* spp., *Poa* spp., and *Elymus scaber*, and pasture species such as *Phalaris aquatica* and *Dactylis glomerata* is limited by dormancy and other water saving strategies that restrict gas exchange during periods of high light intensity and temperature. The potential for such pastures to use water is less under grazing because animals selectively remove green leaf.

It is often believed that trees are an essential component of the water balance of wooded plant communities. However, studies in Western Australia have shown that summer active pastures can provide an equivalent level of control over deep drainage (Fig. 3) (Carbon *et al.* 1982).

Figure 3. The deep drainage component of the water balance for forest and a number of different pasture types growing in a 900 mm rainfall area on deep sand in Western Australia (Carbon *et al.* 1982).



In south-eastern Australia, Aston and Dunin (1980) estimated that planting *Pinus radiata* over previously cleared lands in a subcatchment of the Shoalhaven River NSW would significantly reduce streamflow. In the Murray-Darling Basin, where water quality and streamflow are related, such an effect could lead to significant reductions in water quality, particularly in dry years or if the proportion of the catchment's water yield used for irrigation increased. In the Shoalhaven River, reductions in streamflow were estimated to be due to increased evapotranspiration by the trees and increased direct evaporation from tree canopies (interception loss).

## Grasslands, the nitrogen cycle and the impact of grazing

### Pasture development and soil acidification

As summer active plants decline in pastures, and growth patterns become more seasonal and restricted to the winter-spring period, changes also occur in patterns of nitrogen accumulation and use. Nitrogen, which enters the grazing system through fixation by symbiotic bacteria in nodules on the roots of legume plants, is relatively unavailable when grass swards are growing at high rates in spring. However as herbage dies off and breaks down, or is grazed and nutrients are returned to the soil as dung and urine, mineral (ammonia) nitrogen is released back to the soil. Mineral nitrogen is further broken down as part of the nitrogen cycle to soluble nitrogen (nitrate), which is the form most readily taken up by plants. This process occurs even if the soil is dry. Soluble nitrogen is the fuel that drives the productivity engine of pasture, and in southern Australia it reaches highest concentrations in soil in late summer and autumn (Simpson 1987).

The combination of increased nitrogen inputs through the use of superphosphate and clover, and the loss of plants that have a capacity to utilise soluble nitrogen as it becomes available in summer, leaves nitrate nitrogen available to be leached by the same water that goes to waste as deep drainage. Loss of previously fixed nitrogen through leaching 'opens' the nitrogen cycle and causes soils to become more acid. This ultimately has a 'feedback' effect and, over time, species that are not tolerant of the conditions associated with low soil pH lose thrift and persistence.

Ecosystems typical of hill lands are naturally well adapted to acid soils. If they contain a range of summer active perennial species, rates of soil acidification are low (Crocker & Holford 1991). Because it is not feasible or economic to apply lime to pastures, management should aim to preserve the perennial grass base and thus maintain an effective mineral nitrogen sink so that nitrate does not accumulate at rates sufficient to accelerate the acidification process.

### Grazing effects

Hilly landscapes are typically poorly managed. They have traditionally been set-stocked for long periods, and most are less productive than low-slope lands and are not seen to warrant the investments needed in order to manage them well. Most hill lands also occur 'out-the-back' where they are out of sight and out of mind. Hill lands are places for grazing wethers and ewes after weaning, where all the gates are left open during droughts so that animals can roam, and where a few rabbits can be shot at when city cousins come to visit. Everybody seems to have some out-the-back country, but few landholders really look after it.

Pastures on hill lands are irreplaceable. Many have reached the point where perennial grasses have gone forever. Given their low productivity and the low persistence of sown perennial pasture grasses, even hills that can be cultivated are uneconomic to sow at current costs and prices, and if they are sown once, they will need to be sown again and again. The cost of mismanaging hill lands and allowing them to deteriorate is therefore considerable.

Set-stocking is very damaging to grasslands that contain an array of species of varying palatability and growth patterns. When pastures are grazed at low stocking rates, palatable species become overgrazed when pasture growth exceeds demand. When growth declines, less palatable species, which were not grazed, lose quality and animals suffer a declining plane of nutrition even though herbage availability may be high. This results in patch grazing where animals maintain areas of better pasture by grazing them more often (Fig. 4). Sheep, in particular, ignore areas that accumulate excessive forage. As dung and urine becomes concentrated on the grazed patches, annual species become more dominant. Grazed patches in pastures become a focus for weed invasion and soil erosion, over time they become linked by stock tracks, and they increase in area during droughts.

Loss of palatable species and patch grazing are part of the process of change. Species that escape being grazed, because they are unpalatable or small and inconspicuous, and species capable of being moved around by sheep are favoured by set-stocking.

These include low-growing species of Wallaby Grasses (*Austrodanthonia* spp.), Weeping Grass (*Microlaena stipoides*), Spear Grasses (*Stipa* spp.) and various coarse, unpalatable tussock-forming species such as Wire Grass (*Aristida* spp.), Poa, Serrated Tussock (*Nassella trichotoma*), African Lovegrass (*Eragrostis curvula*), Chilean Needle Grass (*Nasella neesiana*) and Bent Grasses (*Agrostis* spp.) (Fig. 5). (A large number of herbaceous species such as Crowfoot (*Erodium crinitum*), thistles, heliotrope and Cape Weed (*Arctotheca calendula*) also invade over-grazed patches.) In some situations, low-growing summer active Red-leg Grass (*Bothriochloa macra*) may become more prominent as fertility declines, along with lovegrasses (*Eragrostis* spp.), Sporobolus and Couch Grass (*Cynodon dactylon*).

### Soil erosion and nutrients in runoff

Although runoff volumes in southern Australia are highest when soils are saturated in winter, high intensity storms in late spring and summer considerably increase the potential for soil erosion. The erosion risk is highest when the amount of cover provided to the soil surface by standing vegetation and litter is less than about 70% (Costin 1980). Ground cover in heavily grazed, summer dormant pastures is often less than 70% by late summer, particularly during drought.

The loss of surface-applied nutrients in runoff is an important catchment management issue. Fertiliser application is necessary to maintain persistence of sown pasture grasses and sustain production, however phosphorous and nitrogen loss rates may be up to 4 times higher, and 2 times higher for improved pastures compared to native pastures (Young *et al.* 1996).

Figure 4. Grazed patches developing in set-stocked experimental paddocks at Wagga Wagga. Patches develop because the same areas are grazed repeatedly. Annual species and less palatable species invade the patches. Eventually, sheep lose condition because the standing forage has very low forage value.

Figure 5. Serrated Tussock (*Nassella trichotoma*) and African Lovegrass (*Eragrostis curvula*) gaining a foothold in over-grazed paddocks on the Monaro NSW. Less palatable species will always invade if opportunities are provided by poor management.

## Hill land pastures- achieving sustainability

The key to managing water and containing rates of soil acidification on hill lands is to maintain a strong perennial grass base in pastures, and encourage species that are capable of summer growth. On the Tablelands of NSW and in other high rainfall environments, year long green $C_3$ species may reduce nitrate accumulation and deep drainage and protect the soil from runoff if they are naturally competitive. However, on more arid sites and in lower rainfall areas, $C_4$ grasses would seem to be essential for green leaf production in summer.

Grazing of hill pastures may not in itself be detrimental, and for the foreseeable future grazing is likely to remain the dominant landuse. However, set stocking and its associated problems of over-grazing and under utilisation is not sustainable and is a major cause of pasture decline. Pasture improvement practices need to be tailored to the landscape. On sloping lands, soil needs to be protected during periods of high soil erosion risk to minimise the loss of nutrients in runoff. Pastures need to remain stable so summer active perennial grasses are maintained, water is used in summer, and the nitrogen cycle remains closed. ‘Boom-bust’ cycles created by infrequent applications of high rates of fertiliser, and overgrazing during drought, are particularly damaging. Native pastures can be grazed heavily, using high stock numbers for short periods, provided they are allowed adequate time to recover.

Past expectations that hill lands could be ‘improved’ to levels similar to that of more favourable landscape classes is a major cause of their present dysfunction. Achieving a balance between production and catchment protection without compounding the many problems that are emerging within the Murray-Darling Basin, is the main challenge for the future.

Trees are not a panacea or quick fix for current problems. The landscape elements involved are extensive and trees are expensive. The majority of cleared hills contain some residual, adapted native grasses. These need to be revived and encouraged through better management, so they recruit and once again achieve prominence.

Achieving small improvements in summer ground cover and water use over most of the landscape may be a more attainable and effective goal than concentrating an equivalent effort on a smaller area. On a per hectare basis, the amount of water moving to watertables is small, only 5 to 30 mm per year—mostly only a bucket-full per square metre. The challenge facing those who manage the land is to find ways of using this small amount of water year after year, over most of the vast area making up the eastern margin of the Murray-Darling Basin.

## References

Allan, C., Millar, J. & Noble P. 1995. Perennial pastures in the upper Murray - a report on a landholder survey undertaken in North East Victoria. Technical Report, Agriculture Victoria, Wodonga.

Aston, A.R. & Dunin, F.X. 1980. Land-use hydrology: Shoalhaven New South wales. *Journal of Hydrology* 48: 71-87.

Anon. 1989. *Land Degradation Survey of New South Wales 1987-1988*. Soil Conservation Service of NSW, Sydney.

Blackmore, D. & Connell, D. 1997. Are rural land practices in the Murray-Darling Basin a threat to the environment? *Australian Journal of Soil Research* 35: 1037-47.

Burch, G.J., Bath, R.K., Moore, I.D. & O'Louhlin, E.M. 1987. Comparative hydrological behaviour of forested and cleared catchments in southeastern Australia. *Journal of Hydrology* 90: 19-42.

Carbon, B.A., Roberts, F.J., Farrington, P. & Beresford, J.D. 1982. Deep drainage and water use of forests and pastures grown on deep sands in a Mediterranean environment. *Journal of Hydrology* 55: 53-64.

Costin, A.B. 1980. Runoff and soil and nutrient losses from an improved pasture at Ginninderra, Southern Tablelands New South Wales. *Australian Journal of Agricultural Research* 31: 533-46.

Crabb, P. 1997. *Murray-Darling Basin Resources*. Murray-Darling Basin Commission, Canberra.

Crocker, G. J.& Holford, I. C. R. 1991. Effects of pasture improvement with superphosphate on soil pH, nitrogen and carbon in a summer rainfall environment. *Australian Journal of Experimental Agriculture* 31: 221-4.

Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. & Leigh, J.H. 1981. *Plants of Western New South Wales.* Soil Conservation Service of NSW, Sydney.

Hattersley, P.W. 1983. The distribution of $C_3$ and $C_4$ grasses in Australia in relation to climate. *Oecologia (Berlin)* 57: 113-128.

Johns, G.G. 1981. Hydrological processes and herbage production in shrub-invaded poplar-box (*Eucalyptus populnea*) woodlands. *Australian Rangelands Journal* 3: 45-55.

Johnston, W.H. 1996. $C_4$ grasses in temperate agriculture. *New Zealand Journal of Agricultural Research* 39: 457-64.

Johnston, W.H., Clifton, C.A., Cole, I.A., Koen, T.B., Mitchell, M.L. & Waterhouse, D.B. 1999. Low input grasses useful in limiting environments (LIGULE). *Australian Journal of Agricultural Research* 50: 29-53.

Kemp, D.R. & Dowling P.M. 1991. Species distribution within improved pastures over central NSW in relation to rainfall and altitude. *Australian Journal of Agricultural Research* 42: 647-59.

Moore, C.W.E. 1953. The vegetation of the south-eastern Riverina New South Wales I: The climax communities. *Australian Journal of Botany* 1: 485-547.

Moore, R.M. 1959. Ecological observations on plant communities grazed by sheep in Australia. *Biogeography and Ecology in Australia* (series Monographiae Biologicae) 8: 500-13.

Moore, R.M. 1965. Ecological effects of grazing on grasslands in south-eastern Australia. In: *Proceedings of the 9th International Grasslands Congress*, pp. 429-33.

Munnich, D.J., Simpson, P.C. & Nicol, H.I. 1991. A survey of native grasses in the Goulburn district and factors influencing their abundance. *Australian Rangeland Journal* 13: 118-29.

MDBMC (Murray-Darling Basin Ministerial Council) 1987. *Murray-Darling Basin Environmental Resources Study*, July 1987. State Pollution Control Commission, Sydney.

Simpson, J.R. 1987. Nitrogen nutrition of pastures. In: J.L. Wheeler, C.J. Pearson, G.E. Robards (eds) *Temperate Pastures*, pp. 143-54. Australian Wool Corporation, CSIRO, Australia.

Specht, R.L. 1972. Water use by perennial evergreen plant communities in Australia and Papua New Guinea. *Australian Journal of Botany* 20: 273-99.

Young, W.J., Marston, F.M. & Davis, J.R. 1996. Nutrient exports and land use in Australian catchments. *Journal of Environmental Management* 47: 165-83.

Whalley, R. D. B., Robinson, G. G., & Taylor, J. A. 1978. General effects of management and grazing by domestic livestock on the rangelands of the Northern Tablelands of New South Wales. *Australian Rangelands Journal* 1: 174-90.

# Cropping native pasture and conserving biodiversity: a potential technique

Christine Jones

Department of Land and Water Conservation
PO Box 199a, Armidale NSW 2350
cjones@dlwc.nsw.gov.au

Many agricultural activities have negative impacts on the environment. However, agriculture and the environment need not be diametrically opposed. Practices, such as grazing and cropping, that once devastated native grassland communities can, when implemented in non-traditional ways, enhance biodiversity, percentage groundcover, soil structure, levels of soil biological activity, mineral cycling and hydrological balance. Grasslands need grazers as much as grazers need grasslands. Crops are healthier when sown into a permanent, living groundcover base. The more component parts in an ecosystem, the greater the synergy.

Traditionally, it has been considered necessary to remove all existing vegetation prior to an annual crop being sown, and regarded as good management for fallows to be 'clean'. As a result, conventional farming techniques create biological deserts. Very few living things inhabit the soil during long fallows and the situation improves little in a monoculture cropping phase. However, the economic imperative for cropping remains.

This paper describes a pasture cropping technique that utilises a niche in the growth cycle of what remains of overgrazed or previously cropped native grasslands that have lost cool season perennials almost completely. $C_3$ crops such as wheat and oats are direct drilled into the dormant $C_4$ grass base, without cultivation or chemical fallow. Grain yields are good, input costs are low and the warm-season pasture is available for grazing immediately after crop harvest. Pasture cropping combines cropping and grazing into a single, compatible system of land management that improves soil and crop health and the biodiversity and biomass of degraded grasslands.

*Keywords: redesign, regenerative-agriculture, permanent-groundcover*

## Introduction

Most current forms of primary production in Australia result in losses in biodiversity, biological activity and hydrological function in soils, in comparison to the 'natural' ecosystems they replaced. The resulting landscape dysfunction inevitably leads to an increased incidence of pests and diseases and plant, animal and human nutrient deficiencies. These 'problems' are merely symptoms of a system out of balance. In the words of Professor Stuart Hill, Foundation Chair of Social Ecology at the University of Western Sydney, our agroecosystems need to be 'redesigned at every level', to enable natural processes to perform the functions we have inadequately tried to replace with modern technology, particularly chemical technology (Hill 1998, 1999).

Agriculture and the environment need not be diametrically opposed. Grasslands need grazers as much as grazers need grasslands. Crops are healthier when sown into a permanent, living, groundcover base. The more component parts in an ecosystem, the greater the synergy. Let's not miss opportunities to use agricultural activities to regenerate natural resources by remaining restricted by current methodologies.

## Cropping

Traditionally, it has been considered necessary to remove all existing vegetation prior to an annual crop being sown, and regarded as good management practice for fallows to be 'clean'. As a result, conventional farming techniques create biological deserts. Very few living things inhabit the soil during long fallows, and the situation improves little in the monoculture cropping phase. However, the economic imperative for cropping remains. Permanent groundcover and biodiversity are essential for healthy ecosystem function in all forms of agricultural production, and some of the most spectacular benefits associated with maintaining them are to be seen in cropping enterprises.

This paper describes a technique involving the direct seeding of an annual crop into permanent, perennial native pasture. It improves percentage groundcover, soil structure, organic matter levels, water holding capacity, crop health, and the biodiversity and biomass on the type of degraded grasslands involved. Improvements such as these will ultimately benefit rural communities through their impact on farm profitability, and are also extremely important for the restoration of hydrological balance on catchment and regional scales.

## The Cluff-Seis pasture cropping technique

Fifth generation farmers Darryl Cluff ('Olive Lodge' Birriwa) and Col Seis ('Winona' Gulgong) have grappled with the development of workable and regenerative solutions to the severe land degradation problems in the Birriwa-Gulgong area in the Central West of NSW for many years. Lateral thinking, teamwork and daring to be different have been essential ingredients for the development of their 'pasture cropping' technique.

Early European settlers found the perennial grasslands on the flat to undulating country in the Central West of New South Wales highly productive and ideal for raising livestock. However, the winter-active perennial grasses and highly palatable native legumes rapidly disappeared due to set-stocking and failure to reduce stock numbers during droughts. The Seis family grew their first wheat crop in the Gulgong district in 1882, and cropping soon became a major enterprise for most farmers.

Traditional techniques that involved the complete removal of all vegetation resulted in vast tracts of bare ground both before and after cropping. These areas were often recolonised by relatively unpalatable perennial grasses and naturalised annual weeds. Soil erosion on arable land became extensive, particularly in the period 1910-1970, accompanied by soil structural problems and rapid nutrient decline. Fortunately, the dense tree cover on the surrounding rocky ridges remained more-or-less intact.

The long-term average annual rainfall in the Birriwa–Gulgong district is around 600 mm (24 inches), with a slight summer dominance, although it is unpredictable and highly variable within and between years. In 1995, following an 18 month drought during which he thought long and hard about the effects of traditional cropping practices, Cluff direct-drilled an oat crop into a dormant native Redgrass (*Bothriochloa*) pasture in which sub-soil moisture levels at sowing were zero, yet the crop performed well. The pasture cropping technique was born!

The following year, Cluff began experimenting with wheat, and his Landcare colleague Col Seis tried pasture cropping oats, some grown without herbicide application. Their crops were sown with an Agrowdrill direct drill seeder with 30 cm row spacings, approximately 35-40 kg seed/ha, and 85-135 kg/ha of 'Granulock 15' fertiliser (N15:P12:S12) dropped into the rows with the seed.

The Cluff-Seis pasture cropping technique utilises a niche in the growth cycle of what remains of overgrazed or previously cropped grasslands that have lost cool season perennials almost completely. $C_3$ annual crops such as wheat and oats are direct drilled into the dormant $C_4$ warm-season perennial native pasture base, without cultivation or chemical fallow. The roots of the dormant $C_4$ grasses help to maintain soil structure and reduce erosion risks during the cropping phase, while the groundcover of litter maintains biological activity and reduces wind speed, evaporation and weed invasion.

Grain yields have been above average, input costs are extremely low, and the relatively undisturbed warm-season pasture is available for grazing immediately after crop harvest. Over summer and autumn, the pasture is rotationally grazed at high stock density. In the words of Darryl Cluff, the concept 'combines farming and grazing into a single, compatible system of land management'.

Cluff and Seis are now experimenting with the re-sowing of *Themeda*, *Paspalidium* and *Urochloa* [syn. *Brachiaria*] species with some of their crops. This has been made possible by the development of the 'Scorpion' brush seed harvester and 'Germinator' seeder, enabling locally occurring native grass seed to be harvested and re-sown. The production of such highly innovative equipment (with more to come) has been the result of ideas generated by Cluff, Seis, and other members of the

Barneys Reef Landcare Group, and skilfully transformed into engineering masterpieces in the hands of Doug Seis, Col's cousin.

In most cropping areas in Australia, the native pasture base has been permanently lost, making it difficult initially for regenerative practices such as the Cluff-Seis technique to be used. However, now that productive native grasses can be re-sown with crops and nurtured via the pasture cropping technique, millions of acres of farmed land currently suffering severe soil degradation and dryland salinity problems could be rehabilitated. As with the development of pasture cropping, the fine-tuning of the machinery capable of harvesting and re-sowing the often difficult seeds of native grasses and legumes has required much creative thought, testing, observing, discussing and re-testing, devotion to teamwork, countless late nights and the occasional beer.

Pasture cropping is an example of the distinction I make between 'sustainable' and 'regenerative' agriculture. Despite the adoption of 'sustainable' cropping practices such as stubble retention and minimum tillage over much of NSW, we continue to lose an average 7 kg of soil for every kg of wheat produced. It isn't good enough. The breakthrough with pasture cropping is that the aim is to produce high-yielding grain crops **and** improve the vigour and diversity of the grassland **and** improve the condition of the soil. This is not possible with any other cropping method practised in Australia. Over time, soil should be formed, not lost. As organic matter levels and surface condition improve, it is hoped that neither herbicides nor seed drilling will be necessary with the pasture cropping technique. Several experimental areas were broadcast sown this year, with pasture simply slashed on top of the seed.

## Conclusion

There are many possible paths to regenerative agriculture, but it is hard to escape the fact that most of them will require radical departures from current thinking. Traditional thinking has got us where we are now, and more of the same can only make things worse. New technologies embracing a much broader view of ecosystem function need to become an integral part of agricultural production.

Changes to land management that improve biodiversity and groundcover can move us beyond destructive agriculture, beyond the bandaid measures of sustainability, and on to a new era where things are continually getting better rather than worse. Many cumulative benefits are likely to accrue to improved land management. These are not confined to the obvious physical, chemical and biological improvements in soils and vegetation seen to date. Associated benefits include the enhancement of water quality in aquifers and rivers, the possibility of marketable carbon credits for organic matter increases in soil, and, of course, the far-reaching implications for human health and well-being.

Living soils and healthy aquifers were taken for granted when natural resources were abundant. In the next millennium, fresh water will become one of the world's most coveted resources. Many aquifers, even in Australia, have become polluted, saline or dysfunctional due to inappropriate land management practices.

Regenerative agriculture requires new approaches to learning about the natural world. In the past we have strived to increase yield by minimising variation within the system. It has been part of our cultural heritage, encouraged by government provisions, to remove entire communities of native plants and replace them with monocultures of introduced trees or crops or limited species pastures. In response to the ensuing environmental and fertility stresses, we have attempted to maintain production through the use of non-renewable resources such as fertilisers, pesticides and fossil fuel, rather than exploring ways to rebuild natural capital through improvements in ecosystem function. Let's change attitudes, think creatively, and practice regenerative agriculture in biodiverse landscapes. Innovative thinkers such as Darryl Cluff and Colin Seis are showing us how it can be done.

## Acknowledgments

Sincere thanks to Darryl Cluff and Col Seis for providing information on their land management practices.

## References

Hill, S.B. 1998. Redesigning agroecosystems for environmental sustainability: a deep systems approach. *Syst. Res.* 15: 391-402.

Hill, S.B. 1999. Conservation Challenges and Opportunities for the Future. A presentation to New solutions for Sustainability: Integrated Natural Resources Management Conference March 4-5, 1999, University of Sydney, Camperdown.

# Managing grassland composition with grazing

D. R. Kemp

University of Sydney, Orange
Sustainable Farm Management Group & CRC for Weed Management Systems
Leeds Parade, ORANGE NSW 2800
david.kemp@oac.usyd.edu.au

Grasslands are diverse mixtures of native and exotic, desirable and less-desirable species. Over recent years it has been increasingly accepted that the composition of grasslands is influenced by grazing practices and consequently that grazing management can be a valuable tool in managing composition. Several principles have evolved to achieve better management of grasslands with livestock, and new tools have been developed to monitor the status and trends in grasslands.

To use grazing to manage grassland composition, the principal tactics are to rest desirable species during periods when they are more sensitive to grazing and to pressure the less-desirable components at their more sensitive stages. An essential component in the use of these tactics is to control the ability of animals to select what they eat. Usually some form of rotational grazing is beneficial. In large, continuously grazed areas it is rarely possible to manage grazing. Patch grazing is a typical result. Grazing tactics include managing the frequency and intensity of grazing and the duration of rest periods. In some cases, grazing to sustain higher amounts of herbage mass may produce as satisfactory a result as rotational grazing.

Many grassland species are more sensitive to grazing when regenerating from seeds or buds, when flowering and when recovering from periods of stress, e.g. after droughts, floods, fire, frosts. To effectively use such tactics it is important to be able to adequately assess the composition of the grassland under study, to define the major phenological patterns and then to design an appropriate grazing protocol. The animal species involved is also important; sheep are more selective than cattle, while goats prefer more fibrous species. Kangaroos appear to require a slightly higher quality feed supply than sheep. The potential for use of grazing as a management tool is only starting to be more widely exploited. It can be more cost-effective than other practices and can be successfully integrated into overall farm management. Often apparent conflicts are minimal with careful thought and re-organisation. To achieve sustainable grassland systems, grazing needs to be more effectively managed.

*Keywords: grazing, composition, management*

## Introduction

Grassland management is an under-developed science in Australia. This is a consequence of several factors. Livestock producers have, for obvious reasons, focused more on the condition and performance of their animals than on the plants beneath their feet, while research into grazing practices was often inconclusive. This research was often short-term and the main criterion for evaluation was, again, animal performance. Many past experiments did not monitor in any detail possible changes in vegetation. Much management has been reactive rather than proactive. In addition, the general attitude developed that most plants are insensitive to grazing practices, the main exception being Lucerne (*Medicago sativa*). Against these attitudes was the clear evidence that many grasslands had changed or degraded under grazing (e.g. Moore 1970). When Europeans first settled in Australia, they operated as if most species could tolerate whatever grazing pressure they wanted to apply. As a consequence, many species disappeared from grasslands. The pre-European grasslands were replaced by volunteer weeds or non-indigenous native grasses. The same happens with many sown pastures.

In recent years, there has been a growing recognition that the impact of grazing, particularly on grassland composition, has to be better managed. Most people are familiar with gross over or under-grazing, but we are yet to develop a suitable set of widely accepted guidelines to define more ecologically sensitive grazing practices. Some managers do an excellent job and have evolved their own rules as to an appropriate level of grazing pressure, but these have not been translated to and/or taken up by the majority.

An emerging issue is the management of grasslands for sustainability and biodiversity. Some areas have been successfully managed for these purposes over the years, but the rules used are not always certain. The challenge for commercial properties with areas of native and naturalised grasslands is to develop strategies that enable sustainable and profitable production while achieving local biodiversity aims. There is likely to be some common ground to enable all these (potentially conflicting) aims to be resolved.

In this paper, the principles involved in managing the composition of grasslands by grazing will be outlined and some of the ways they can be implemented will be discussed. One of the more difficult challenges facing grassland managers are weeds like Serrated Tussock (*Nassella trichotoma*). The serious nature of this weed has been documented since the 1930s (Fallding 1957; Campbell 1998). Examples will be presented of how grazing practices could be used to help reduce the impact of this weed. The suggestions made are based upon an understanding of how grasslands function, but have not been tested in experiments.

## Aims of grassland management

To consider the use of grazing for grassland management within the context of this meeting, it is useful to first consider the aims of grassland management, given broader objectives. For this discussion, only perennial grasslands are considered, rather than short-term forage crops or leys within a cropping rotation.

- For livestock production—the aim of grassland management is to maintain a high proportion of productive species, growing at optimal rates and with sufficient biomass to sustain optimal animal growth rates. In most cases there are several species within the grassland e.g. grasses and legumes.
- For sustainability—grassland management needs to maintain ground cover, to minimise erosion, and to maintain green leaf to transpire soil water to limit rising water tables and associated problems with soil salinity. Keeping plants active will help maintain root systems to capture more nitrates and thereby reduce acidification problems. Over-grazing is likely to restrict root function (Kemp & Culvenor 1994).
- For biodiversity—the aim is to maintain a diverse range of species and some diversity in the structure of the grassland. Minor species become more important. The relationship between grasslands and native fauna needs to be considered.

In each of the above, there are common elements relating to the number of species to be maintained and the minimum amount of biomass to which grasslands should be grazed.

There is a common aim to maintain desirable species over the long-term, the actual species varying with circumstances. For production and biodiversity, a range of species is important. For production, the optimal species number could be in the range of 6-10 (Tilman 1996; Nichols *et al.* 1997). More plant species and functional groups will be important for biodiversity. Additional species will often be minor contributors to production. Such species could, however, have important ecological functions for fauna habitat and as ‘gap-fillers’ to limit weed invasion. Grazing would need to be managed in ways that limit any selective grazing of these minor species. Desirable species need to be maintained in a productive, competitive state to limit weed invasion.

To sustain grassland growth rates, animal intake, transpiration rates, minimise erosion and protect small species, there is a need to maintain the standing biomass above a minimum threshold. What that threshold should be will depend upon the grassland species and broader management objectives.

## Principles for manipulating composition and maintaining species

To successfully use grazing management to manipulate grassland composition, some basic conditions need to be satisfied and a few rules apply (Wilson & Hodgkinson 1990; Kemp 1991, 1993). The main considerations are:

- All grassland plants are more or less sensitive to grazing. This sensitivity varies with stages in their growth cycles, soil fertility and seasonal conditions. In general, plants are most sensitive when: germinating; as seedlings; when regenerating from buds; and during flowering. When germinating and regenerating from buds, plants run down their energy reserves. When flowering, vegetative growth is often suppressed and reserves are used for stem, flower and seed production. Plants are more sensitive to stress and management near the limits of their ecological range. When using grazing to manipulate composition, the aim is to attack less-desirable plants during the weak points in their life cycle (e.g. as seedlings) or when recovering from some stress (e.g. herbicide, fire *etc*.), and to minimise grazing of desirable species during weak points of their life cycle.

- The grassland needs to contain some desirable species. The greater the proportion of desirable species, the easier and faster it is to change composition. If there are insufficient desirable species then they need to be introduced. Desirable species potentially exist in the soil seed bank even if there are few or no mature plants.
- The undesirable species need to be considered. Unpalatable plants such as Serrated Tussock can be made less competitive by mechanical and/or chemical tactics.
- Stocking rate is the key to manipulating composition in many cases. By varying graze and rest periods, and controlling when animals can be selective and when they cannot, considerable influence is exerted on the grassland.
- In mixed grasslands, difficulties arise where both desirable and less desirable species have similar growth cycles. This means grazing tactics often need to be a compromise.
- Paddock fertility and seasonal conditions are important. The better the conditions for growth, the faster the plants will grow and respond to management, and the faster changes in composition will occur. Adequate nutrition can promote the forage value of less desirable species and encourage animals to eat them.
- Animal species vary in their grazing preferences. Sheep tend to be more selective than cattle and can therefore put more pressure on desirable species. Goats prefer more fibrous plants and some browsing. Kangaroos require a higher quality diet than sheep. These differences can be usefully exploited.
- Changing grassland composition can take some time. It may take a few years to increase the desirable perennial grass component of a grassland where it is necessary to allow plants to flower, set seed and then for that seed to germinate and establish new plants. You may need to wait for an appropriate season to amend composition-it's difficult to make much progress in a drought.

The management of grassland composition by grazing often comes down to controlling the ability of animals to select what and how much they eat, and giving desirable species every chance to be competitive and to persist. Set stocking in large paddocks rarely provides any opportunities for grazing management, unless animals are shepherded. In this context, temporary electric fencing can be used as the technical equivalent of the traditional shepherd.

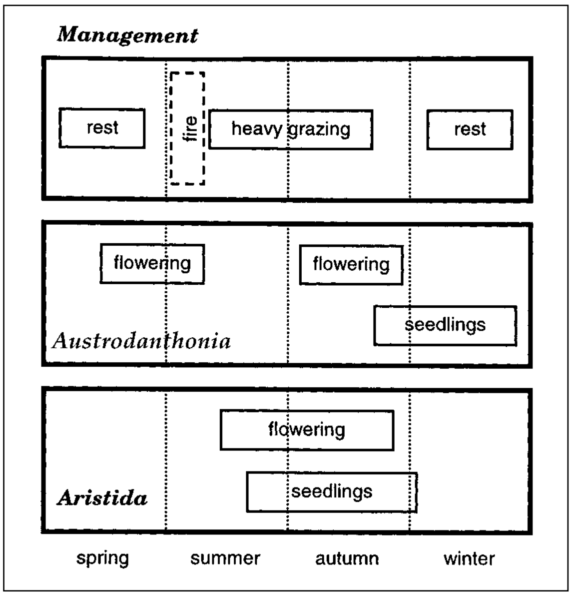
### Strategic grazing

To manipulate the botanical composition of grassland, two complementary strategies are often used. These are: to use crash grazing with high stock numbers when less desirable species are at a weak point in their life cycle; and the converse, of lax or 'deferred grazing' when desirable species are at a weak point. The main weak point that most grazing strategies concentrate on is the period of reproductive development. The implementation of such practices needs to be based on an understanding of the phenology of the grassland.

Crash grazing has been used in one of the more notable successes in recent times. This has been done in the Wire Grass (*Aristida ramosa*) program developed at Tamworth (Figure 1; Lodge & Whalley 1985). An initial rest in spring lets Wallaby Grass (*Austrodanthonia* spp) flower and set some seed. Heavy grazing when Wire Grass is flowering then helps reduce its seed set. The third component is to then rest the grassland when *Austrodanthonia* seedlings are establishing. The effects are enhanced if the heavy grazing follows an early summer burn. Heavy grazing of Serrated Tussock has been tried (Campbell 1998) and found to be ineffective, but Wire Grass is not much more palatable than Serrated Tussock and it is possible this could work, possibly after a burn to encourage young shoots. The grazing doesn't necessarily aim to kill plants, but to reduce seed set and shift the balance in seed produced towards components that are more desirable. To be effective, some subdivision, even on a temporary basis, may be needed to control grazing pressures.

Previously on the NSW Northern Tablelands, crash grazing for a week in spring was shown to greatly

Figure 1. Phenological development and grazing management of Wire Grass in a Wallaby Grass grassland (based on Lodge & Whalley 1985).




reduce the occurrence of Nodding Thistle (*Carduus nutans*) (Medd 1979), another largely unpalatable species. The effects were enhanced if grazing was combined with the use of a cheap herbicide.

Deferred grazing (i.e. resting) is one of the easiest techniques to use. The feasibility of this approach has been examined in several projects in central NSW. Rests during autumn and winter (depending upon the time that reliable rainfall starts) often increase the legume content of grasslands, which then makes the grassland more attractive to animals. With a better diet, animals then consume less desirable species more readily. Rests over summer also enable many species to set seed and for seedlings to establish, depending upon rainfall. At one site at Newbridge, Cocksfoot (*Dactylis glomerata*) content was increased from 10% to 40% over three to four years by summer rests (Kemp *et al.* 1993).

Deferred grazing is a useful technique that can fit in easily with normal farm plans. This technique is applied on a paddock basis, rather than to the whole farm at once. Many livestock producers rest their paddocks at various times without major difficulties. The main concern is often what to do in drier seasons, but that need not become a major problem. Paddocks are rested to enable desirable plant species to complete life cycles, i.e. to flower, set seed and for that seed to germinate and establish new plants.

These processes are more likely to occur in good years. In those years, resting a paddock is unlikely to have any great impact on farm livestock production. In dry years the desirable events are less likely to occur and hence if rested forage is needed, animals can graze the rested paddock without unduly affecting the overall strategy. Grazing of such paddocks still needs to be managed such that any damage to the desirable species, compared with the less desirable, is minimised. Quick and less-selective grazing is preferred.

Grazing management should always be integrated with other options. There are also some specific tactics with grazing within integrated strategies. Where herbicides are likely to be used, but desirable species are sensitive to those herbicides, grazing can be used to quickly remove the leaves from those species to reduce the damage from herbicide.

Grazing plans need to become part of day-to-day management. Once the goals for a paddock are decided then plans can be developed to achieve those goals. It is important to remember that desirable change can take some years, and that the grassland can also deteriorate again quickly if inappropriate management is used.

Grazing plans may need to be staged in phases. Often the first phase is to reduce less-desirable species to some tolerable level. Initial tactics would aim at limiting seed set by those species and the weakening, and hopefully death, of the mature plants. Subsequently, it would be important to limit the establishment of seedlings from those species. Many of the less-desirable species in grasslands would be expected to have a significant soil seed bank, which would be a source of re-infestation for many years. If necessary, a further phase would aim to encourage the recruitment of more desirable species. These sequences can be seen in Figure 1.

## Fertility

The rate of change in grassland composition depends upon site fertility. Higher nutrient levels will increase rates of plant growth and the rates of change. Some species such as Subterranean Clover will not be very productive at low nutrient levels, yet they can be significant competitors when managed appropriately. Ungrazed subterranean clover can be a strong competitor against some perennial grass seedlings and can smother them. Use of rests after the autumn break could then enable greater growth and competition from subterranean clover against less desirable species e.g. Serrated Tussock. When opened to grazing, stock would probably consume any Serrated Tussock seedlings within a thick legume sward. This approach was successfully used for three years to reduce Barley Grass (*Hordeum leporinum*) in grassland at Grenfell (Kemp *et al.* 1993).

### Supplementary feeding

Don't feed in grasslands that are already overgrazed e.g. in dry seasons. It is better to use a sacrifice area where stock can be confined. It has been argued that animals will substitute supplementary feed for grassland. However, that is likely to be too simple an explanation. Usually animals are fed energy feeds such as grain. In such cases they will seek a protein source, which is likely to be any green pick. Typically you do see animals picking at the grassland in areas where supplementary feeds are given. The same often applies when feeding grain, hay or silage. Where you want to protect the grassland and encourage the recovery of desirable species-avoid feeding livestock in those areas.

## Managing herbage mass

Grasslands that are continually over-grazed do not satisfy the goals of livestock production, sustainability or biodiversity. Heavily grazed grasslands usually shift towards less-desirable components and more bare ground. One way of managing grasslands is to set criteria for the lower boundary values below which grasslands should not be grazed. This is a useful approach once the composition of the grassland is in a desirable state, and to help maintain the grassland in that state. It can also be useful when manipulating the composition of the grassland to a desirable state. In this case, the lower boundary values for herbage mass applies only to the desirable components to minimise any overgrazing of those species.

Boundary values for grazing (Kemp 1991) will vary with species, soil fertility, rainfall and season. Under high fertility and good rainfall, plants can often be grazed low to the ground and still survive and be competitive. The main problem is when plants are under stress from dry seasons, low fertility etc., and that is when they should be monitored more closely (Kemp *et al.* 1997). On the Central and Southern Tablelands of NSW this is probably in late spring to early summer, as the season dries off, and until some time after the autumn break. In addition, as droughts develop, grasslands need to be monitored to enhance the ability of desirable species to survive and be competitive. We need to develop suitable boundary values, such as using the tools taught in Prograze courses, so that grasslands can be effectively monitored and stock moved as required (Kemp & Michalk 1993).

Desirable species within grassland need to be monitored to maintain minimum values of herbage mass (sometimes called FOO, i.e. forage-on-offer) during these more stressful seasons. The object is to monitor desirable components and estimate their biomass. This approach has not been specifically tested in experiments, but indirect evidence has accumulated from a range of sources over recent years (Kemp *et al.* 1997). For low fertility areas with small tussock species such as some Wallaby Grasses, we have proposed that they should not be grazed below the equivalent of 0.5 t DM $ha^{-1}$ (estimate on a square metre basis). In more fertile native grasslands this figure should be 0.7-0.8 t DM $ha^{-1}$ to allow for the more upright growth that occurs and the greater vigour of the weeds. By contrast, large tussock species, e.g. *Phalaris aquatica* cv Sirosa, probably require a herbage mass above 1.5 t DM $ha^{-1}$ to persist through droughts. Experiments at Orange suggested that 1 t DM $ha^{-1}$ was appropriate for medium sized plants like Cocksfoot. These values are for persistence of the desirable species. Higher values may be required to enhance their competitiveness against weeds. This is an area that requires research. To apply this approach it is important that desirable species be differentiated from weeds, and that land managers have some experience in directly estimating forage yield. In large paddocks where it is not practical to move stock around, setting minimum boundary values for desirable species may be the only way to minimise overgrazing and retain desirable species. The values for herbage mass are ideally for green material, however, they can serve as a general guide for total dry matter in dry seasons.

Keeping the herbage mass above these limits does help reduce grazing pressures. Applying these rules in dry seasons can result in an earlier reduction in stocking rates, but often has the effect of increasing the available forage per DSE, e.g. at low stocking rates there can be 0.5 t DM $DSE^{-1}$. This means the remaining animals are more adequately fed than otherwise and the need for supplementary forage is reduced.

## Examples of strategies

The ideas discussed above can be used to formulate proposals for grazing management of Serrated Tussock infested grasslands. Two proposals are formulated for discussion, based upon $C_3$ or $C_4$ desirable perennial grasses being in the grassland. The objective is to take an active approach to grazing management and to target specific paddocks. They have not been tested in the field and I welcome discussion on their feasibility. The timing of graze and rest periods should be based upon specific information on the actual phenology of the species within a paddock. The spread of Serrated Tussock has been aided by grazing practices, but little has been done using grazing to limit or reverse its spread. Grazing management can be used to maintain grasslands in a competitive state, and to limit invasion by Serrated Tussock and/or keep its presence to a low level. Grazing tactics may not be of much use in heavy infestations. Ideally, the proportion of desirable perennial grasses should be twice that of Serrated Tussock to effectively use grazing tactics to control the weed. Thus, grazing tactics have a role in light to medium infestations and in maintenance of grasslands after other tactics have been used to reduce heavy infestations.

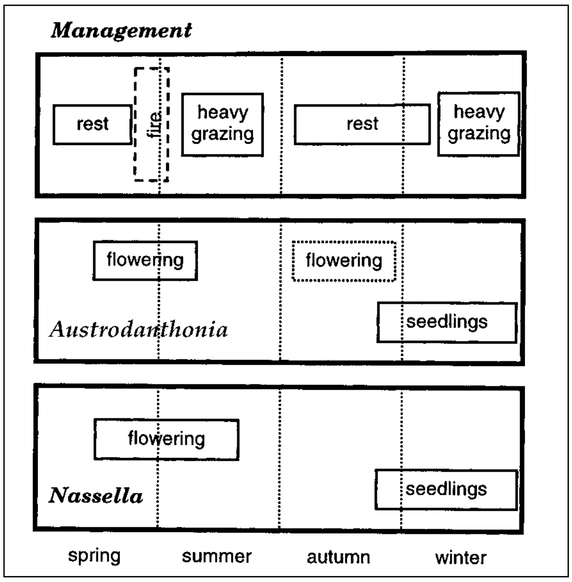
The first example considered is a Serrated Tussock, Wallaby Grass and Subterranean Clover grassland (Fig. 2). In this case it is assumed that the Serrated Tussock infestation is <20% and that there is 30-40% Wallaby Grass and fertiliser has also been applied. The similar developmental patterns in Serrated Tussock and Wallaby Grass, means there are only a couple of points where differential treatments can apply. The main periods of flowering, seedlings etc. are shown. The aims in this strategy are to:

1. reduce seed inputs from Serrated Tussock with rest, fire and heavy grazing (cattle and sheep will often remove seed heads), or low application rates of glyphosate (note: Wallaby Grass is extremely sensitive to glyphosate);
2. increase seed set from Wallaby Grass with a rest in late summer;
3. reduce establishment of Serrated Tussock seedlings by resting in autumn and winter to allow Subterranean Clover to increase and dominate the sward, then heavy grazing to consume any Serrated Tussock seedlings within the clover (graze when the herbage mass reaches 0.8$^{-1}$ t DM ha$^{-1}$-which may not be until late winter);
4. manage the grassland conservatively at other times to encourage establishment of more Wallaby Grass plants by not grazing the desirable components below 0.5-0.8 t DM ha$^{-1}$; and
5. use spot spraying etc. to remove individual weeds.

This combined approach seeks to promote the prevalence of desirable species in the soil seed bank. Heavy grazing is best done quickly to minimise grazing the regrowth of desirable species. The expectation with Serrated Tussock is that heavy grazing is unlikely to kill plants. The model offered here is based on the results with Wire Grass (discussed earlier) where fire and heavy grazing did help control it. There is very little published literature (e.g. Campbell 1961) on the impacts of a late spring, early summer burn and heavy grazing on Serrated Tussock. It would be worthwhile testing and may prove to be useful. This proposed strategy would need to be applied over a few years to enhance the seed bank of desirable grasses and limit establishment of new tussock plants.

The above procedure is for a fertilised paddock. In unfertilised areas where Subterranean Clover isn't an important component, the same steps could still be used, though the impact of a rest and heavy grazing in autumn/winter may not be as great. Having Subterranean Clover in the grassland will increase rates of change and could improve the forage value of Serrated Tussock for livestock.

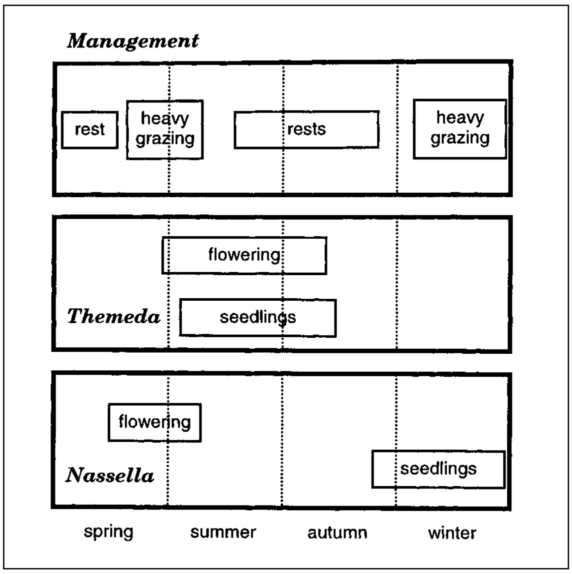
Figure 2. Generalised proposal for management of Serrated Tussock in a Wallaby Grass, Subterranean Clover grassland.



The second example considers a Serrated Tussock, Kangaroo Grass (*Themeda triandra*) and Subterranean Clover grassland (Fig. 3). In this case there are fewer major conflicts in development patterns between the Serrated Tussock and Kangaroo Grass. The components of this strategy are:

1. rest, fire and heavy grazing in late spring to reduce seed set by the Serrated Tussock (the alternative is a low rate of glyphosate);
2. a rest over summer to allow $C_4$ species to grow, set seed and seedlings to establish, depending upon rainfall;
3. rest over the autumn/winter period when subterranean clover is establishing until there is $0.8^{-1}$ t DM $ha^{-1}$, when heavy grazing can be used to help remove any Serrated Tussock seedlings;
4. manage the grassland conservatively at other times to encourage establishment of Kangaroo Grass by not grazing the desirable components below 0.5-0.8 t DM $ha^{-1}$; and
5. use spot spraying *etc.* to remove individual Serrated Tussock.

Figure 3. Proposed strategy for managing a Serrated Tussock, Kangaroo Grass, Subterranean Clover grassland.




## Discussion

The impact of grazing on grasslands is widely appreciated, but to date most grazing management has tended to be reactive rather than proactive (Hutchinson 1992). Current research does aim to clarify how grazing tactics are best used to manipulate grasslands, and how those tactics can be combined into proactive strategies to achieve the multiple aims of productive livestock systems that can also satisfy the goals of producers and society for more sustainable and biodiverse ecosystems.

This paper has primarily focused on the management of grasslands used for livestock production on farms. Most research has been aimed at solving problems for that system. However, the same principles will apply in the management of grasslands for nature conservation purposes. Almost by definition, most grasslands are subject to some grazing. If grazing is totally withdrawn there is a strong chance that more dominant shrubs and trees will invade these ecosystems. The management of grazing with native animals such as kangaroos, or by feral rabbits is a more challenging task, but one that does need to be addressed. In some native systems it may be appropriate to use domestic livestock at appropriate times as 'lawn-mowers', to reduce the impact of invading weeds. This could be done with safeguards that minimise the introduction of additional weed problems. The ultimate management system will need to be a compromise, but it should be possible to make effective progress.

## Acknowledgments

The ideas presented here have grown from many discussions with colleagues, particularly within NSW Agriculture and from research projects funded by Meat and Livestock Australia, the Woolmark Company and the Land and Water Research & Development Corporation.

## References

Campbell, M.H. 1961. Burning aids in the control of serrated tussock. *Agricultural Gazette of New South Wales* 72: 311-13.

Campbell, M.H. 1998. Biological and ecological impact of serrated tussock (*Nassella trichotoma* (Nees) Arech.) on pastures in Australia. *Plant Protection Quarterly* 13(2): 80-86.

Fallding, H. 1957 Social factors in serrated tussock control. *Research Bulletin No 1.* University of Sydney, Department of Agricultural Economics.

Hutchinson, K.J. 1992. The grazing resource. *Proceedings Sixth Australian Agronomy Conference*, pp. 54-60.

Kemp, D.R. 1991. Defining the boundaries and manipulating the system. *Proceedings of the Sixth Annual Conference, Grassland Society of NSW*, Orange, pp. 24-30.

Kemp, D.R. 1993. Managing pastures by grazing. *Proceedings of the Eighth Annual Conference, Grassland Society of NSW*, 8: 32-8.

Kemp, D.R., & Culvenor, R.A. 1994. Improving the grazing and drought tolerance of temperate perennial grasses. *New Zealand Journal of Agricultural Research* 37: 365-78.

Kemp, D.R., Dowling, P.M., & Michalk, D.L. 1993. *Management and legume performance: Developing new guidelines for NSW tableland pastures*. Report to Wool Research & Development Corporation.

Kemp, D.R. & Michalk, D.L. 1993 (eds). *Pasture Management: Technology for the 21st Century*. CSIRO, Melbourne.

Kemp, D.R., Lodge, G. & Virgona, J. 1997. Keeping your pastures through drought. *SGS Prograzier* 1(4): 1-7. Meat Research Corporation.

Lodge, G.M. and Whalley, R.D.B. 1985. The manipulation of species composition of natural pastures by grazing management on the Northern Slopes of New South Wales. *Australian Rangeland Journal* 7: 6-16.

Medd, R.W. 1979. Control of *Carduus nutans* in permanent pasture. *Proceedings 7th Asian-Pacific Weed Science Society Conference 1979*, pp. 177-9.

Moore, R.M. 1970. Australian Grasslands. In R. Milton Moore (ed.) *Australian Grasslands*. Australian National University Press, Canberra.

Nichols, P.K., Kemp P.D., Barker, D.J., Brock, J.L. & Grant, D.A. 1997. Production, stability and biodiversity of North Island New Zealand hill pastures. *Proceedings 18th International Grassland Congress* 21:9-10.

Tilman, D. 1996. Biodiversity: Population versus ecosystem stability. *Ecology* 77:350-63.

Wilson, G. & Hodgkinson, K. 1990. The response of grasses to grazing and its implications for the management of native grasslands. In: P.M. Dowling & D.L. Garden (eds) *Proceedings Native Grass Workshop*, pp 47-57. Australian Wool Corporation, Melbourne.

# Session 7

## A Broader Look at Grassy Landscapes

# Conservation of biodiversity in grazed landscapes: some patchy principles

David Freudenberger

Sustainable Landscapes Program
CSIRO Wildlife & Ecology
GPO Box 284, Canberra 2601
d.freudenberger@dwe.csiro.au

Some plants and animals thrive under intense grazing, many are neutral and some are seriously threatened by the direct and indirect effects of grazing. The conservation of native biota requires us to recognise the landscape requirements of these threatened species. That is, how much land, in what sorts of configurations, and with what sorts of habitat elements and management interventions are required to conserve those species that cannot tolerate the grazing and fragmentation we've imposed across the landscape? Redesigning landscapes to meet the spatial needs of the most sensitive species threatened by grazing and fragmentation (focal species approach) may provide an efficient means of integrating conservation into agricultural landscapes. The homogenisation of our farmscapes needs to end, and patchy heterogeneity must be enhanced if on-farm conservation is to succeed.

## Introduction

The one thing most grasslands have in common is that they are grazed, often by large mammalian herbivores. This grazing shapes the very nature of grasslands. Without grazing, grasslands change; with grazing they also change in response to inputs of precipitation, prolonged periods of desiccation and bouts of grazing at various times, intensities and duration. Grazing is a pervasive process that shapes grasslands in a myriad of ways.

This paper outlines the likely impacts of grazing on biodiversity in temperate grassy landscapes with examples from the rangelands. I argue that grazing needs to be a spatially and temporally patchy process, because patchiness is essential for the maintenance of biodiversity. I'll then provide an example of one way to identify the size, configuration, number, and structure of patches needed in grassy woodlands to provide suitable habitat for those species that are unable to survive under the current agricultural regime of continuous grazing, cropping, or intensive pasture management.

## Impact of grazing - winners & losers

We will never know exactly how ecosystem biodiversity is affected by disturbances such as grazing. Most species in any ecosystem are likely to remain largely unknown to science as they are microscopic and reside in the soil or in intestines of invertebrates and vertebrates. But we do know that some groups of organisms thrive under disturbances such as grazing, while others decline and many are neutral. This is most easily recognised in plants. Researchers have defined plant species as increasers or decreasers based on their ability to persist under specified grazing regimes (e.g. Dyksterhius 1949; Ellison 1960; McIvor 1998). Some plant species are increasers because they avoid being grazed by various structural deterrents such as spines, or contain biochemical compounds that reduce their palatability or digestibility to herbivores. Other plant species can avoid deleterious effects of grazing by rapid growth and prolific seeding and proficient seedling establishment typified by ephemeral herbs (Hodgson & Illius 1996; Landsberg *et al.* 1999a).

Disturbances such as grazing by mammals affects more than just plants. Grazing can have direct impacts on a wide suite of invertebrates that feed on plant material, or indirect effects on many animals through changes in habitat structure, e.g. the invasion of unpalatable shrubs or the local extinction of palatable shrubs and grasses (Landsberg *et al.* 1999a). A recent and comprehensive study (Landsberg *et al.* 1999b) of the impact of grazing on biodiversity in rangelands was based on surveys of a wide range of taxa at increasing distances from eight watering points in the acacia and chenopod rangelands of Australia. Grazing by native, feral and domestic mammals was most intense near (0-1 km) the watering points and absent for most of the time at the furthest points (<8 km). This study provides us with the best view of how grazing is likely to affect biodiversity in grazed landscapes. On average, between 15% and 38% of species in different taxonomic groups appeared to be 'decreasers' (i.e. declined in abundance with increasing grazing pressure); between 10% and 33% appeared to be increasers; and the remaining species did not exhibit any demonstrable response along the gradient out from each watering point (Table 1).

It is important to note that this study did not find a consistent response for species richness along each gradient of grazing pressure. At one gradient the number of species increased as distance from the watering point increased, at another gradient the number of species declined away from the water. The conservation of biodiversity should not focus on species number, but rather focus on species composition. This study consistently found that some species, from a diverse range of taxa, only occurred at the most distant point from water (least grazing pressure; Table 2). It is not known whether these species are dependent on the absence of grazing and remoteness to water, or whether their unique occurrence was due to natural variation in species distribution across the landscapes. The regional significance of the species that were only present at sites with low grazing pressure are currently being investigated (James *et al*. 1999).

What is clear and consistent from the Landsberg *et al*. (1999b) study is that some species are favoured by grazing, some are negatively affected, and many are tolerant of rangeland grazing pressures. The challenge is to actively conserve those species that are threatened by the proliferation of grazing that has been imposed on most of the Australian continent by the provision of watering points, the near elimination of predation by dingoes, and the intense management of domestic livestock (Freudenberger *et al*. 1997).

## Other impacts - vegetation clearance

Grazing modifies habitat in grassy landscapes. In contrast, clearing, particularly for cropping, destroys habitat. Clearing of some plant communities (e.g. grasslands and grassy woodlands) has been nearly total in some regions (SOEAC 1996). The impacts of these activities continue to have enormous effects on biodiversity—though the detail is poorly known (Hobbs 1993). Some species are possibly thriving, even in cultivated paddocks. Hundreds of native beetles were recently found in pitfall traps in the middle of a stubble paddock in central NSW (D. Driscoll pers. com.). But the effect of such widespread clearing has likely lead to the extinction of other species, many of them never known to science since we know so little about the pre-clearing distribution of invertebrate and microbial species.

We also know that many species now survive only in remnants of the grassy woodlands of temperate Australia (Bennett *et al*. 1998). These remnants are often no more than a few isolated trees or strips of native grasses on the margins of roads and paddocks. The habitat for many native species is now fragmented into small islands buffeted by wind, grazing, fertilisers, agro-chemicals, weeds, and feral predators. Some species thrive under this

Table 1. The proportion of species that either increased in abundance (Increasers) with increasing grazing intensity, or were apparently unaffected by grazing intensity (Neutral), or decreased in abundance (Decreasers) under increased grazing intensity along 8 gradients 0-10 km from artificial watering points in the rangelands of Australia (from Landsberg *et al.* 1999b).

| Taxa | Total No. Spp | % Increasers | % Neutral | % Decreasers |
|---|---|---|---|---|
| Understorey plants | 90 ± 11 | 26 ± 4 | 36 ± 7 | 38 ± 8 |
| Overstorey plants | 23 ± 5 | 10 ± 5 | 75 ± 10 | 15 ± 7 |
| Plants in soil seed bank | 77 ± 8 | 33 ± 4 | 44 ± 7 | 23 ± 7 |
| Birds | 30 ± 5 | 17 ± 7 | 59 ± 11 | 23 ± 8 |
| Reptiles | 16 ± 1 | 18 ± 8 | 60 ± 11 | 22 ± 7 |
| Ants | 76 ± 8 | 24 ± 8 | 50 ± 9 | 26 ± 7 |

Table 2. Number and proportion of species found only at the site furthest (8-10 km) from a permanent (artificial) watering point along 8 gradients in the Australian rangelands (adapted from Landsberg *et al.* 1999b). The site furthest from the watering point is assumed to be the site with the lowest grazing pressure.

| Taxa | Total No. Spp | No. found only distant from water | % found only distant to water |
|---|---|---|---|
| Understorey plants | 91 ± 11 | 8 ± 1 | 9 ± 1 |
| Overstorey plants | 23 ± 5 | 2 ± 1 | 7 ± 3 |
| Plants in soil seed bank | 80 ± 8 | 4 ± 1 | 4 ± 1 |
| Birds | 29 ± 5 | 2 ± 1 | 4 ± 1 |
| Reptiles | 16 ± 1 | 2 ± 0.5 | 9 ± 3 |
| Ants | 76 ± 8 | 4 ± 1 | 5 ± 1 |

disturbance regime (e.g. the Noisy Miner and scarab beetles), but like the rangeland example of Landsberg *et al*. (1999b), there are many species that are declining under the progressive fragmentation of the grassy woodlands. Some bird species are locally extinct while others continue to decline in the temperate agricultural zone (Saunders & Ingram 1995; Robinson & Traill 1996).

The fragmentation of these woodlands will never be fully reversed. Our demands for food and fibre are such that agriculture and grazing will not be extensively abandoned in the temperate grassy landscapes. The challenge is to reduce the scale and intensity of fragmentation. Like the rangelands, we need to identify those patches in the landscape that are required for the conservation of the decreasers—those species that cannot survive in the agricultural matrix of intensively grazed or cropped paddocks.

## Sustainable fragmentation

The focal species approach proposed by Lambeck (1997) is proving to be a useful means of quantifying the limits to fragmentation. To prevent the further loss of species from landscapes threatened by habitat loss, fragmentation, and habitat simplification, it is necessary to determine the composition, quantity and configuration of habitats required to meet the needs of those species that are still present. The focal species approach identifies a suite of sensitive species, each of which is used to define the configuration and composition of habitats that must be present in the landscape. The species that is identified as being most sensitive to a threat in the landscape is termed the ‘focal’ species. For example, area-limited species are used to define the minimum area required for different habitat patches, and dispersal-limited species define the proximity of patches and the need for connecting vegetation. It is assumed that because the most demanding species are selected, a landscape designed and managed to meet their needs will encompass the requirements of all other species. Lambeck (1999) used this approach to define minimum areas for revegetation and the minimum connectivity needed in various regions of the Western Australian wheat-sheep zone.

## A case study

I’ve recently used this approach to provide conservation and revegetation guidelines for the ACT and bordering NSW landscapes within the Southern Tablelands. These ‘variegated’ landscapes are less fragmented than those in the cropping zones of Australia as they are characterised by a stippling of small and large woodland remnants in a matrix of exotic and semi-natural grasslands with an abundance of isolated trees (McIntyre & Barrett 1992). The focal species approach provides a procedure for analysing threatening processes in the landscape and was used during a community workshop to identify landscape threats as part of a Natural Heritage Trust revegetation project run by Greening Australia ACT and South-east NSW, Inc. (Freudenberger 1999). We focused on the threats of habitat loss, isolation, and modification of patches of grassy and shrubby woodland around the ACT. This focus was consistent with the fact that Yellow Box/Red Gum Grassy Woodland is an endangered ecological community in the ACT because of agricultural and urban encroachment (ACT Government 1997). We aimed to determine the most sensitive species threatened by loss, isolation and modification of habitat in the project area. We did this in order to produce recommendations for the minimum sized areas that the Greening Australia project should help replant, their location and their structural composition (e.g. understorey).

Lambeck (1999) and S. Briggs (pers. comm.) have found birds to be useful focal species. Many birds use landscapes at the planning scale of hectares (paddocks) and kilometres (properties). Birds are relatively easy to survey because of their abundance and visibility during the day. Birds are also useful because they are placed well to the top of food chains. Many woodland birds feed on a wide variety of insects (Ford 1986), which in turn require a mixture of plant species. Thus, the habitat requirements of focal birds species are likely to encompass the needs of a wide range of other biota.

Presence and absence data were collected from 72 remnants (sites) in the northern ACT and in the surrounding region in NSW (Freudenberger 1999; Watson 1999). These data were obtained from several sources, including data from the Canberra Ornithological Group, though most of the data were collected during 20-minute active searches conducted specifically for this study. Survey sites (grassy/shrubby woodlands) ranged in size from 1.1 ha to 1617 ha, with a median size of 20 ha. The isolation index (mean distance to five nearest remnants) ranged from 0.3 to 3.8 km, with a median isolation of 1.25 km.

Structural diversity, encompassing the cover of different vegetation layers of each survey site, was measured using a rapid appraisal method first developed by Newsome and Catling (1979) to explain the diversity of mammals found in a wide range of habitats. At each site, a habitat complexity score, modified from the one described by Catling and Burt (1995), was derived on the basis of six features: tree canopy cover, tall (2-4 m) shrub cover, short (0.5-2 m) shrub cover, ground herbage cover, the relative amounts of logs and/or rocks, and the relative amount of ground litter (Watson 1999). Each feature was rated on a scale of 0–3, and the scores for the six features were totalled to give an overall score. A score <5 represents a woodland with poor structure with no understorey shrubs and little herbage (grasses and forbs) ground cover. A score of 5–9 represents a woodland with moderate structure comprising > 20% shrubs and 10–50% cover of ground herbage, logs and litter. A score >10 describes a structurally complex woodland with high shrub, herb and litter cover.

The woodland birds found in this study were allocated to three groups in terms of their sensitivity to landscape scale threats:

1. Tolerant—those bird species that occur in simplified landscapes (e.g. the pastoral matrix) or in small patches (<10 ha) with little understory, and that are unaffected by isolation;
2. Moderate—those that occur only in moderate size (10 ha–100 ha) and complex patches, or in small (5–10 ha), well-connected (isolation <1000 m) and complex patches (habitat complexity 6–12);
3. Sensitive—those that occur only in large (>100 ha) patches or highly complex and heterogenous patches (habitat complexity >12).

Few woodland birds were found in patches smaller than 10 ha and with a habitat complexity score <6 (Freudenberger 1999; Watson 1999). Those sites below 10 ha that contained moderately sensitive woodland birds were invariably well-connected

Figure 1. (a) The effects of woodland patch area and habitat complexity on the presence/ absence of the Rufous Whistler, and (b) the effects of area and isolation for the same bird; arrows show minimum area and habitat complexity recommended to suit moderately sensitive woodland birds in the ACT and bordering region of NSW (From Freudenberger 1999).

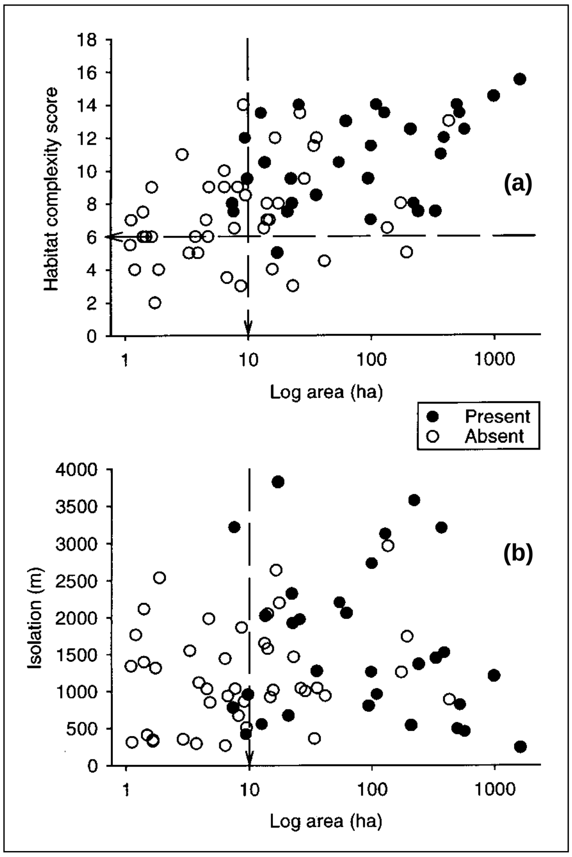
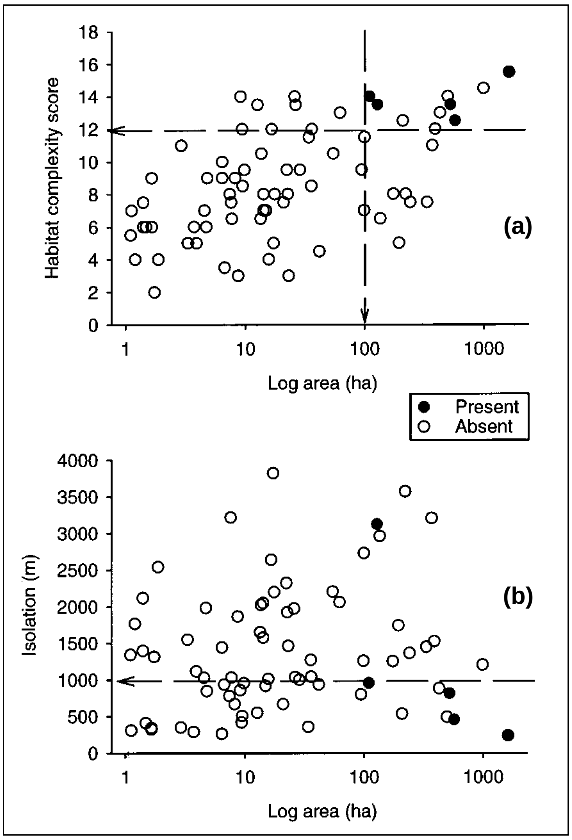


Figure 2. (a) The effects of woodland patch area and habitat complexity on the presence/ absence of the Hooded Robin, and (b) the effects of area and isolation; arrows show minimum area and habitat complexity and maximum isolation recommended to suit sensitive woodland birds (from Freudenberger 1999).




(isolation index 500–1000 m). For example, the two sites below 10 ha that had Rufous Whistlers were sites in which the isolation index was below 1000 m (Fig. 1). Isolated sites (>2 km) with sensitive woodland birds were almost always sites larger than about 20 ha.

The Hooded Robin was most sensitive to all three landscape factors of area, isolation and habitat complexity (Fig. 2). Thus the Hooded Robin is the focal species for the woodlands of the northern ACT and bordering region of NSW. Of the species observed, it had the most demanding requirements for patch size and habitat complexity. At minimum, the Hooded Robin appears to require structurally complex woodlands (≥20% tree canopy cover with ≥20% cover of shrubs 0.5–4 m in height, and ≥40% cover of ground plants and logs or rocks and leaf litter) of over 100 ha in area that are within about 1 km of other remnant patches of woodland. These spatial and compositional features are likely to provide suitable habitats for all the other woodland bird species recorded during this study. Landscape patches of this size, internal structure and placement in the landscape will likely suit the needs of other groups of plants and animals, but this prediction needs testing.

Even with the best intentions, Natural Heritage Trust revegetation initiatives will not be able to create many 100 ha sites over the next few years within the ACT and bordering NSW region. It may take decades to achieve sufficient density of fallen timber to meet the needs of the Hooded Robin. Clearly, an intermediate objective was required for the Greening Australia project.

I suggested that the needs of the large number of moderately sensitive bird species in the region be an intermediate objective. These bird species appear to need vegetation patches at least 10 ha in size with moderate habitat complexity (woodland with >20% shrub cover and 10–50% cover of ground herbage, logs and litter). This should be an achievable goal because the majority of woodland remnants in the region are near 10 ha in size and a suitable habitat complexity score of 6 can be rapidly created by excluding livestock and planting shrubs to cover over 20% of the ground.

## A starting point

The focal species framework, developed and tested in the Western Australian wheatbelt, provided a useful starting point for the Greening Australia vegetation enhancement project in the ACT and bordering region of NSW. My project team was able to rapidly obtain a simple but valuable data set on which I was able to recommend the following priorities:

1. Conservation of woodland patches larger than 100 ha is critically important. Some species need these large and internally heterogeneous patches to persist in the landscape. Habitat structure continuously changes as trees mature and senesce (Catling & Burt 1995). An appropriate disturbance regime of fire and grazing needs to be maintained in order to provide suitable habitat for those species that cannot persist in uniformly old (senescent) woodlands.
2. Those woodland patches that are larger than the critical 10 ha need enhancing by controlling grazing (fencing) and re-introducing native

shrubs and grasses where appropriate. The internal habitat structure or complexity is of critical importance. Some tree thinning may be required to open up the canopy to promote shrubs and allow the felled timber to provide additional habitat structure for birds like the Brown Treecreeper and those reptiles and invertebrates that also need such ground level structure.

3. Those remnant patches that are less than 10 ha need rebuilding to a size larger than 10 ha, with an appropriate understorey of shrubs and native grasses. In the ACT and bordering region of NSW, the majority of remnant woodlands fall within this category.

## How much is enough?

Will a patchwork of medium sized (10-100 ha) woodland patches with a diverse understorey of shrubs and grasses be adequate to maintain self-sustaining populations of birds and other biota? How dense should this patchwork be? The analysis of our focal species data set provides some answers. A few patches of suitable size and habitat complexity were not occupied, apparently because they were too isolated. Patches within about 1 km of other patches (mean of 5 nearest neighbours) had a higher probability of being occupied than more isolated patches. We had no evidence that corridors were needed, rather a 'stepping-stone' analogy for enhancing landscape connectivity may be more useful—at least for birds.

The focal species approach provides a means of developing explicit landscape predictions. From the analysis of our data set, I predict that a patchwork of >10 ha remnants with a complex vegetation structure, that are located on average within about 1 km of other similarly suitable patches will provide an adequate, though still fragmented, landscape for most woodland bird species. A few larger (>100 ha) patches will also be required within the landscape to provide for those particularly sensitive species such as the Hooded Robin. It will take decades and considerable revegetation to support or disprove this prediction. The alternative to this sort of bold prediction is simply faith that more woodland patches are better than the current situation.

The focal species approach should also provide early indications of success. If moderately sensitive birds like the Rufous Whistler re-appear in enhanced patches where they presently are not found, then revegetation initiatives should be heading in the right direction. If a Hooded Robin or Brown Treecreeper re-appears, a significant milestone will have been reached deserving of celebration.

## At what cost?

I've yet to sit down with the GIS of the ACT/bordering region of NSW and calculate the cost of creating a patchwork of 10 ha patches within 1 km of each other based on enhancing the hundreds of sub-optimal remnants that still exist in this variegated landscape. However, this is one of the strengths of  the focal species approach—landscapes can be redesigned and costed with a reasonable probability that the redesigned landscape will meet the needs of those species still persisting in the area.

The focal species analysis was cost effective. The focal species bird surveys required about 250 hours (25 person days) plus about 800 km of travel. A SPOT satellite image was purchased for the study ($2400) in order to quantify patch area and isolation, but aerial photos held by various agencies, or high quality 1:25 000 ortho-photo maps could have been used. Our early experience with the focal species approach (R. Lambeck & D. Freudenberger pers. obs.) continues to indicate its cost effectiveness. The key resource is competent bird identification skills, which can include amateur ornithologists in many communities. Their skills and passion are needed for designing sustainable landscapes.

## Re-creating patchiness

The rangeland and focal species case studies cited above have been used to support my contention that the conservation of biodiversity within agricultural landscapes is dependent on enhancing landscape patchiness.  An unknown proportion of species will likely only survive in patches where disturbances such as grazing and clearing are at very low intensities. The challenge for land managers and policy makers is, firstly, to prevent the loss of large and/or complex habitat and, secondly, to increase the number and enhance the quality of low-disturbance patches. Relatively large but few nature reserves are critical for some species, but not enough for many others. The focal species framework and analysis provides a means of quantifying the level of patchiness that is required between large reserves and intensively managed pastures and crops.

## Acknowledgments

Ideas for this paper have been contributed by many colleagues, including: Robert Lambeck, Julian Reid, Jill Landsberg and Sue Briggs. Earlier drafts of this paper were considerably improved by helpful comments from Sue Briggs. The focal species case study was supported by the Natural Heritage Trust through Greening Australia SE NSW Inc. Field surveys were conducted by Mark Clayton (CSIRO) and James Watson (Australian Defence Force Academy).

## References

ACT Government 1997. *Yellow Box/Red Gum Grassy Woodland: An Endangered Ecological Community.* Draft Action Plan No. 10, Environment ACT, Canberra.

Bennett, A., Brown, G., Lumsden, L., Hespe, D., Krasna, S. & Silins, J. 1998. *Fragments for the Future: Wildlife in the Victorian Riverina*. Department of Natural Resources and Environment, East Melbourne.

Catling, P.C. & Burt, R.J. 1995. Studies of ground-dwelling mammals of Eucalypt forests in south eastern NSW: the effect of habitat variables on distribution and abundance. *Wildlife Research* 22: 271-88.

Dyksterhuis, E. J. 1949. Condition and management of rangelands based on quantitative ecology. *Journal of Rangeland Management* 2: 104-15.

Ellison, L. 1960. Influence of grazing plant succession of rangelands. *Botanical Review* 26: 1-78.

Ford, H.A. 1986. Birds and Eucalypt dieback in north-eastern NSW. In: H.A. Ford and D.C. Paton (eds) *The Dynamic Partnership: Birds and Plants in Southern Australia*, pp. 150-4. Government Printer, South Australia.

Freudenberger, D. 1999. *Guidelines for Enhancing Grassy Woodlands for the Vegetation Investment Project*. A report commissioned by Greening Australia ACT & SE NSW Inc. CSIRO Wildlife and Ecology, Canberra.

Freudenberger, D., Noble, J. & Hodgkinson, K. 1997. Management for production and conservation goals in rangelands. In: J. Ludwig, D. Tongway, D. Freudenberger, J. Noble & K. Hodgkinson (eds) *Landscape Ecology, Function and Management: Principles from Australia's Rangelands*, pp. 93-106. CSIRO Press, Melbourne.

Hobbs, R.J. 1993. Effects of landscape fragmentation on ecosystem processes in the Western Australian wheatbelt. *Biological Conservation* 64: 193-201.

Hodgson, J. & A. W. Illius (eds) 1996. *The Ecology and Management of Grazing Systems*. CAB International, Wallingford, UK.

James, C., Stafford Smith, M., Bosma, J., Landsberg, J. & Tynan, R. 1999. Production, persistence, economics and extinction: integrating conservation and pastoralism in Australian rangelands. In *Proceedings of the VI International Rangeland Congress*, Townsville, Australia, 2: 659-61.

Lambeck, R.J. 1997. Focal species: a multi-species umbrella for nature conservation. *Conservation Biology* 11: 859.

Lambeck, R.J. 1999. *Landscape Planning for Biodiversity Conservation in Agricultural Regions: A Case Study from the Wheatbelt of Western Australia*. Biodiversity Technical Paper, No.2, Environment Australia, Canberra.

Landsberg, J., O'Connor, T. & Freudenberger, D. 1999a. The impacts of livestock grazing on biodiversity in natural ecosystems. In: H. G. Jung and G.C. Fahey (eds) *Nutritional Ecology of Herbivores: Proceedings of the Vth International Symposium on the Nutrition of Herbivores*, pp. 752-77. American Society of Animal Science, Savoy, IL.

Landsberg, J., James, C.D., Morton, S.R., Hobbs, T.J., Stol, J., Drew, A. & Tongway, H. 1999b. *The effects of artificial sources of water on rangeland biodiversity*. Biodiversity Technical Paper No. 3. Environment Australia, Canberra.

McIntyre, S. & Barrett, G.W. 1992. Habitat variegation, an alternative to fragmentation. *Conservation Biology* 6: 146-7.

McIvor, J. G. 1998. Pasture management in semi-arid tropical woodlands: effects on species diversity. *Australian Journal of Ecology* 23: 349-64.

Newsome, A.E. & Catling, P.C. 1979. Habitat preferences of mammals inhabiting heathlands of warm temperate coastal, montane and alpine regions of southeastern Australia. In: R.L. Specht (ed.) *Heathlands and Related Shrublands of the World: Descriptive Studies*, pp. 301-16. Elsevier, Amsterdam.

Robinson, D. & Traill, B.J. 1996. *Conserving Woodland Birds in the Wheat and Sheep Belts of Southern Australia*. RAOU Conservation Statement No. 10. RAOU, Melbourne.

Saunders, D.A. & Ingram, J.A. 1995. *Birds of Southwestern Australia. An Atlas of Changes in the Distribution and Abundance of Wheatbelt Avifauna*. Surrey Beatty & Sons, Sydney.

Saunders, D.A., Hobbs, R.J. & Margules, C.R. 1991. Biological consequences of ecosystem fragmentation: A Review. *Conservation Biology* 5: 18-32.

SOEAC 1996. *Australia: State of the Environment 1996*. State of the Environment Advisory Council. CSIRO Publishing, Melbourne.

Watson, J. 1999. An assessment of the focal species approach on woodland avifauna within the northern ACT and surrounding areas of NSW. Honours Thesis, University of New South Wales, Australian Defence Force Academy, Canberrra.

# Ecological limits to pasture intensification

Sue McIntyre

CSIRO Tropical Agriculture
Long Pocket Laboratories, 120 Meiers Road, Indooroopilly Qld 4086
sue.mcintyre@csiro.tag.au

Pasture intensification is the result of management aimed at increasing plant and livestock productivity. It involves one or more of: tree clearing, soil cultivation, use of fertilizer, irrigation, and the use of non-native species, and is associated with higher stocking rates than before the management is imposed. Although well-managed sown pastures can sustain high levels of animal production, pasture intensification can threaten long-term production and other natural resources if it exceeds critical thresholds. There are impacts on native plant and animal communities. The most apparent threat to sustainable farming is the loss of tree populations and the resulting salinity associated with intensification. A critical task is to identify landscape thresholds above which pasture intensification causes problems. A proposed maximum area of 30% intensive pastures on properties is discussed. A shared understanding of the significance of land-use thresholds is needed across all institutions dealing with primary production and land-use planning. It might then be possible to balance the capacity of rural landscapes to sustain production with the well-being of rural communities.

*Keywords: landscapes, land-use, ecological limits*

## Intensification and sustainability-an important relationship

The concept of landuse intensification is fundamental to our understanding of sustainable management in rural lands. Intensification involves the diversion of the solar energy captured by plants towards specifically human uses. It may also involve a greater total amount of solar energy being captured. The more intensive the land-use, the more energy is diverted to our own ends and the less available to stabilize ecosystems. In contrast, natural ecosystems have evolved to use solar energy for generating biophysical processes that stabilize biosphere structure and function. Human exploitation of natural systems can be seen as the diversion of solar energy flows from these stabilizing processes in order to stabilize human society. Giampietro *et al.* (1992) regarded the stability of the balance between biophysical capital and human-technological capital as an indicator of the sustainability of human activity. The more our actions divert energy from the biophysical processes of ecosystems, to meet our own needs, the more likely we are to destabilise that system. This is a theoretical explanation for the common observation that intensification of land-use is riskier from a sustainability point of view. There is only a finite amount of energy available to the earth's organisms. If we use it all ourselves, the life-support systems provided for and by other species can be affected.

In grazing systems, pasture and livestock are the means by which solar energy is captured, and provide humans with a direct source of food. By modifying the grassland ecosystem, adding fertiliser and palatable, nitrogen-fixing plants, we can increase the amount of energy captured as carbohydrates in plants and converted into meat by livestock. In a low input system, the biomass production remains similar when stocking rates are raised, but is diverted into livestock rather than providing food and habitat for native plants and animals, including soil invertebrates. In a high input system, fertilisation and cultivation may raise total productivity, but the native biota does not benefit as it has generally been replaced. In both cases, nutrients and exotic species may leak into and de-stabilise adjacent ecosystems.

## What is pasture intensification in the Australian context?

The term 'intensive pasture management' covers the more commonly used terms 'improved', 'developed' or 'sown' pastures and forage cropping. It is the broadest description of practices that are designed to increase animal production on new or existing pastures. Intensification involves one or more of the following practices: tree clearing; cultivation; use of fertiliser and/or non-native species; and irrigation. Higher stocking rates are generally associated with these activities to reap the production benefits and must therefore be considered an integral part of the intensification 'process'. Other management that may be associated with intensification includes inputs such as herbicides and pesticides.

Intensive pasture management usually involves the destruction of native vegetation and its replacement with a sown pasture of non-native species. Other forms of intensification involve the modification of native grassland vegetation, for example, through the use of fertilizer and/or oversowing with legumes. Through their ability to fix nitrogen, legumes can contribute large amounts of nitrogen to pastures. In northern Australia inputs of 40-210 kg N $ha^{-1}yr^{1}$ have been measured (Henzell 1968). Pasture management covers a broad spectrum of the intensification levels, ranging from simple additions of exotic species into a native grassland community to the full range of agronomic practices associated with crop management.

There are two broad patterns of pasture intensification in Australian landscapes. The first is characteristic of vegetation that does not have a native grassland understorey (e.g. rainforest, brigalow, heathland). In this case vegetation is fully cleared and sown, often with soil cultivation, resulting in almost complete replacement of vegetation with crop or exotic pasture species. Ecologically, the extent of clearance of native vegetation and replacement by a cropping landuse is important. An intensive land use is inevitable following clearing, and the sowing of pastures is incidental.

A second situation occurs in landscapes with native grassland or vegetation with a grassy understorey. Intensification practices range from complete replacement as described above, to aerial seeding of exotic species into intact vegetation. A consistent pattern is for sown pastures to be associated with clearing of trees to a few clumps or scattered trees and increased stocking rates. This includes rangelands and the higher rainfall temperate zones. Although the intensification of pastures in grassy vegetation may not initially involve wholesale clearance, the end point may be just that. This process is generally effected over decades through repeated cycles of fertilisation, tree thinning, sowing and heavy stocking rates.

## Why is there concern about pasture intensification?

The use of fertilizers, introduced legumes and grasses has been a major contributor to animal production in Australia. It has enabled the provision of quality forage at critical times of year (Eyles *et al*. 1985) and the success of intensive pastures has meant that, in some parts of Australia, pasture 'improvement' is '*… an article of faith to Australia's farmers and graziers*' (Wilson 1968). Pasture intensification has enabled increased animal production and thus the diversion of more energy into products for human needs and desires. However, maintaining the stability of high production in sown pastures requires increased energy input. Sown pastures need a higher level of management than native pastures to maintain their composition (Teitzel 1992) and continued inputs to maintain the stability of the plant/soil system, e.g. water, lime, fertiliser, cultivation (fuel and machinery) and seeds of sown species. These inputs are drawn from natural resources and their use may have impacts on nearby or distant regions and ecosystems.

The process of diverting and using large amounts of energy and resources for intensive land-uses tends to be an inefficient one. For example, cultivation combined with fertilization is intended to maximize resource capture and, consequently, growth of sown species. While the sown species are establishing there is a period when nutrient availability and exposure of cultivated soil is high. There will be some periods when nutrients and soil are blown, leached or washed away from the cropped area and into other habitats. This 'leakiness' can be a concern when watercourses or native vegetation are affected. Another form of leakiness is when exotic species, i.e. non-native, introduced or alien species, become naturalised and spread beyond their sown area. The impacts of energy diversion and leakiness associated with intensification can be problematic for sustainable production, and are discussed in the following sections.

## Impacts of pasture intensification on native ecosystems

### Conservation status of communities

Some land types are more responsive to intensification processes in terms of productivity increases. The plant communities on these land types are consequently more at risk, and their survival at regional or national level may be jeopardised. For example, in Queensland, brigalow communities and grassy woodlands supporting *Eucalyptus tereticornis* and *E. melanophloia* have been seriously impacted by pasture intensification practices (Sattler & Williams 1999). As land with higher agricultural potential tends to be poorly represented in conservation reserves, the need for integration of conservation management into production systems is a vital part of planning on all properties.

### Grazing pressure

While native grasslands can be subject to heavy grazing, pasture intensification has also been linked with higher grazing pressures (Walpole 1999). Producers have made an investment of resources and management, and need to harvest the production gains. Persistent, heavy grazing of sown or augmented native pastures converts grasslands dominated by large tussocks to lawn-like areas dominated by annuals, stoloniferous grasses and short tussock grasses (Grice & McIntyre 1995). When the large tussocks decline, plant cover and soil organic matter are reduced, pasture growth declines, infiltration rate decreases and soil structure deteriorates (McIvor *et al.* 1995; Thurow 1991). Without careful management, intensification may thus pose a risk to the soil resource. Less well understood is the role of tall tussock grassland in providing for fauna. Litter and seeding plants are a food source for ground feeding birds, while the tussocks themselves provide protection for ground-nesting species (Robinson & Traill 1996; Woinarski 1993). It is possible that leniently grazed exotic pastures may provide some structural habitat for native fauna, but this role has not been studied.

## Impact of intensification on native pastures

Many native species are not well adapted to the environment and disturbances associated with pasture intensification. Figure 1 compares the density of species in sub-tropical native pastures with that in similar vegetation that has been subjected to intensification (cultivation, fertilizer, exotic species sown). The density of native species is considerably reduced, while exotic species density is unaffected. Different disturbances contribute to this effect. Figure 2 shows intermediate effects of intermediate levels of soil disturbance and site enrichment. The same patterns of response in native species were observed in temperate grasslands, however, exotic species showed strongly positive responses to disturbance (McIntyre & Lavorel 1994), while species density of exotics in the sub-tropics was not as responsive to disturbances (Figs 1-3). Grazing in itself does not adversely affect the species density of native plants, in fact density is maximized with some grazing (Fig. 3; McIntyre & Lavorel 1994) although there is a suite of grazing-sensitive species that prefer ungrazed habitats. In summary, it is not grazing *per se* that necessarily impacts on the floristic integrity of grassland vegetation, but the soil disturbance and site enrichment (fertiliser, irrigation) associated with pasture intensification.

Another impact of intensification is the soil chemistry change induced by legume sowing and potentially accelerated by the use of fertilizer. Soil pH levels may decline and it is likely that such changes are going to adversely affect certain pH-sensitive native species, although I am unaware

Figure 1. Species density (number of species in 6m x 6m plots) in sub-tropical grassland near Crows Nest, Queensland. Two habitats are compared: Native pastures = native grasslands grazed at commercial stocking rates by cattle (n = 109 plots); Sown pastures = native grasslands subjected to cultivation, fertilization and sowing with exotic species and grazed at commercial stocking rates by cattle (n = 16 plots).

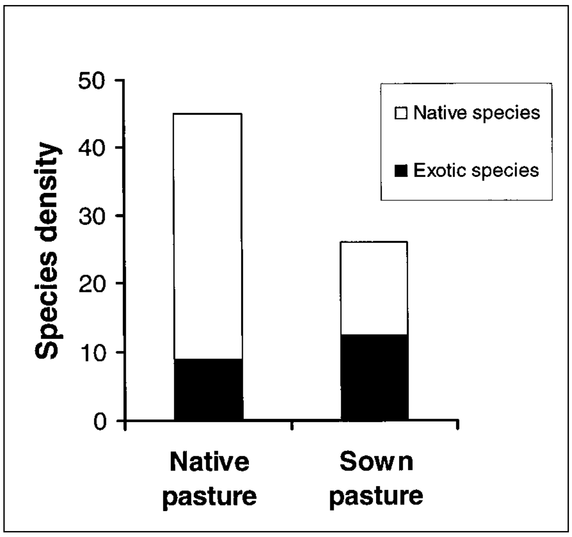


Figure 2. Species density (number of species in 6m x 6m plots) in sub-tropical grassland near Crows Nest, Queensland. Two disturbance types are compared. Soil disturbance compares three levels of soil disturbance evident at the time of sampling: none = no human-induced soil disturbance (n = 161 plots); some = evidence of earthworks or vehicle disturbance (n = 35 plots); cultivation = soil had been cultivated in the previous five years (n = 16 plots). Enrichment compares sites that have: none = no additions of water or nutrients (n = 157 plots); water = more water entering soil that would be received by incident rainfall (n = 39 plots); fertilizer = fertilization of site with or without the use of irrigation (n = 16 plots). Shaded bars = Exotic species; Open bars = Native species.

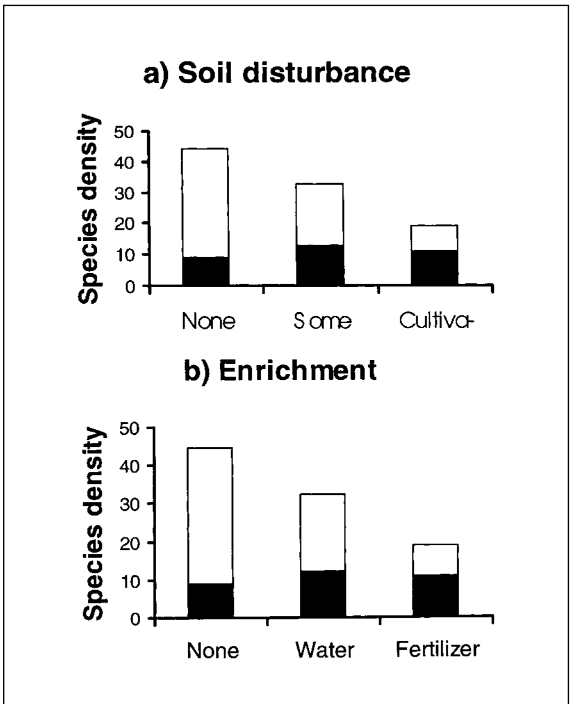
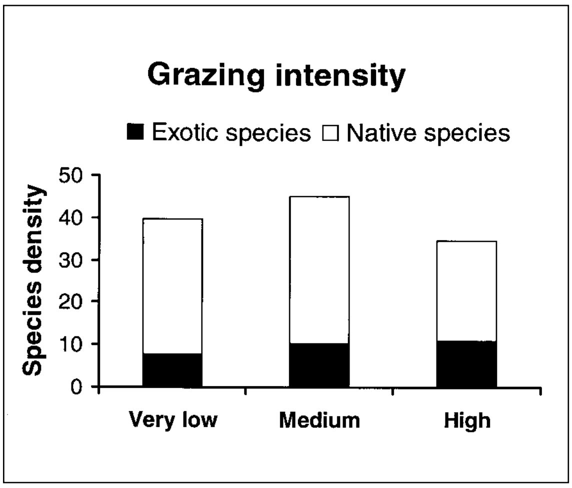



Figure 3. Species density (number of species in 6m x 6m plots) in sub-tropical grassland near Crows Nest, Queensland. Three grazing levels are compared. Very low = habitats that are generally protected from grazing, e.g. roadsides, stock routes (n = 67 plots); Medium = areas in commercial native pastures that are subjected to selective grazing indicated by the dominance of the site by large tussocks (n = 87 plots); High = areas in commercial native pastures that are subjected to non-selective grazing, indicated by the lawn-like structure of the grass sward (n = 58 plots).




of any published documentation of this. Soil acidification is widespread in southern Australia (Williams 1980). More recently, it has also been shown to be a problem in northern Australian grasslands (Noble *et al.* 1997) and it has been suggested that the impacts of legumes should be minimised by restricting planting to small areas in soils with a high pH buffering capacity, and managing the area to reduce the risk of widespread accelerated acidification (McIvor *et al.* 1996).

## Impact of exotic species beyond pastures

The successful use of exotic plants in sown pastures will obviously shift the composition of native grasslands in favour of exotics. This is after all the aim of such management. Of greater concern is when exotics spread beyond sown areas into other habitats such as native grasslands, reserves and roadsides. Sown pasture species have extensively naturalised in Australia, spreading from plantings and accidental introductions. Of 466 grasses and legumes introduced into northern Australia between 1947-1985, 4 were useful, 17 were useful but weedy and 43 were not useful but weedy (Lonsdale 1994). In other words, most of the useful sown pasture species are also agriculture or conservation weeds.

In Queensland, pasture introductions have replaced native species across an estimated 5 million hectares (Walker & Weston 1990). Notable invaders are Buffel Grasses (*Cenchrus pennisetiformis*, *C. ciliaris*), Indian Couch (*Bothriochloa pertusa*), Couch Grasses (*Digitaria didactyla*, *Cynodon* *dactylon*), Rhodes and Panic Prass (*Chloris gayana*, *Panicum maximum*) and Townsville Stylo (*Stylosanthes humilis*). Some taxa, e.g. *Panicum maximum*, *Macroptilium atropurpureum*, are more visually evident in non-pasture habitats such as roadsides than the pastures in which they were originally sown. Dominance by exotic species in disturbed, ungrazed habitats can have a major impact on grassland diversity (McIntyre 1993). It is a significant conservation problem, as grazing-sensitive native grassland plants have few alternative habitats to roadsides, areas which are particularly prone to earthworks and exotic invasions.

## Impacts of pasture intensification on landscape processes

So far, this paper has described the first order impacts of pasture intensification on native vegetation. Less well understood, but possibly more important, are the more indirect impacts that affect the long-term ecosystem health of our rural lands. Pasture improvement is associated with major landscape issues including tree decline (Landsberg & Wylie 1991), vegetation clearance and ultimately phenomena such as dryland salinity (LWRRDC 1995).

### Impacts on tree populations

There are many complex inter-relationships between pasture intensification and the dynamics of tree populations, but fundamentally, extensive intensification can adversely affect the viability of nearby remnant vegetation or the viability of trees growing in grazed woodlands (Old *et al.* 1981; Landsberg & Wylie 1991). Considering the importance of this issue our knowledge is surprisingly patchy. Elements that we have some understanding of include the direct impacts of livestock on trees (trampling of roots, damage to trunks, grazing of seedlings), some climatic interactions (episodes of drought-induced mortality) and some plant/insect/management interactions (Landsberg & Wylie 1983; Landsberg 1988). However, there is no published work on the minimum area of woodland/ forest needed to retain patch viability in relation to tree dieback. One significant study is that of Wylie *et al.* (1993) in Queensland, who found that tree dieback was most severe on properties where fertilisation and improved pasture was most extensive, and on properties that had been established for the longest. Properties with over 50% of the area under sown pasture had tree dieback symptoms that were significantly more severe than properties with smaller proportions of sown pasture. Thus pasture intensification can lead to a process of indirect clearing of tree populations in rural landscapes.

### Salinisation

It may seem a large conceptual leap to link intensive pasture use to salinisation, but as the health of tree populations becomes compromised, populations are reduced and water tables are affected. Tree clearing, however, is a major factor in dryland salinisation (Martin & Metcalfe 1998). Salinisation can, in turn, further contribute to tree decline (Wylie *et al.* 1993). From a landscape perspective, sufficient trees located in the appropriate places must be retained to prevent the rise of groundwater beyond critical levels. Theoretically, exotic trees could perform the same function, but from a conservation and economic point of view self-sustaining populations of local native trees are most desirable. The proportion of woodland/forest cover needed to maintain functioning ecosystems is a matter of some debate and would need to take into account many factors including the viability of habitat for wildlife, hydrology and representation of different vegetation types and landforms. A suggested minimum area of 30% was proposed by McIntyre *et al.* (1999) for sub-tropical grassy woodlands, taking into account our limited understanding of these factors. There is evidence that woodland/forest retention around this level actually maximises the value of pasture output per farm (Walpole 1999).

### Impact of vegetation clearance at the landscape scale

The direct and indirect impacts of intensification on vegetation clearance have now been described qualitatively, but the extent to which clearance occurs across the landscape is important. Very few landscape-scale experiments have been conducted to examine the effects of clearance, so we must look at other sources of evidence. Neutral landscape models are a way of examining the geometry of landscapes, and can be used to explore the degree to which vegetation is connected across the landscape with varying levels of clearing (Pearson *et al.* 1996). Although based on models rather than real life, there are some very important principles that emerge from studies of theoretical landscapes. For example, if a habitat occupies 70% of a landscape (in any arrangement) that landscape still has very high connectivity for the organisms in the habitat. By extension, if native grassland occupies 70% of the landscape all grassland organisms, even those with low levels of mobility, should be able to move though the landscape without leaving the habitat that they are dependent on. This means that organisms would be able to move seasonally, interbreed and escape events such as fires, and the grasslands would be able to maintain ecological functions. In contrast, if woodland or forest was cleared to 30% of the landscape only mobile organisms would be able to freely move through the landscape (i.e. organisms such as birds that are capable of some movement through cleared areas). McIntyre *et al*. (1999) proposed that for variegated habitats, where native pastures were a part of the production system, there should be retention of 70% extensively managed native pastures. As many grassland organisms are of low mobility (e.g. plants with limited seed dispersal and soil invertebrates) this would be a minimum level of retention to retain habitat connectivity.

## What are limits to intensification?

'*To a point (although we do not know precisely where the point is), ecosystems can be simplified and brought under our control and yet still function in the sense of cycling nutrients and transforming energy into useful products. They might even be aesthetically attractive - a pastoral scene for example - although impoverished in many ways that we do not understand.*' Noss (1993)

In this quotation Noss refers to the commonly adopted position that with enough inputs and management, ecosystems such as grassy woodlands can be maintained to fulfil all the basic requirements for continued production. This may require significant inputs of nutrients and pesticides, engineering solutions to rising watertables, and artificial treatment of downstream surface waters. Yet Noss points out that we do not know precisely how much simplification we can achieve while maintaining ecosystem function. Nor do we know whether the costs are going to outweigh the benefits. How much is the loss of species going to impinge on our future? One certainty is that continuing intensification is going to result in the loss of entire native grassy ecosystems, as many of them are entirely restricted to the pastoral zone.

I suggest two reasons to limit intensification on pastoral lands: firstly, to conserve species for their existence value; and secondly, as a risk management strategy. We cannot afford to lose potentially critical ecosystem functions on a nationwide scale. Nor are we in complete ignorance of what these functions are. The vital role of trees is now acknowledged even in the most conservative circles. In Queensland, producers have voted for native pastures. Less than 5% of the State has been sown to exotics, much less than half of the potential area that could be sown (Weston *et al*. 1981).

In setting landscape limits to intensification, it is important to take into account what we know about the habitats of plants and animals, including the ecosystem processes they need to persist. Our review of the requirements of grassy woodlands, briefly outlined in the previous sections, suggests an upper limit of 30% intensive land use in properties and landscapes would be desirable (McIntyre *et al*. 1999). This is based on empirical observations of tree dieback in Queensland, as well as taking into account the need to retain 70% of native grasslands to maintain connectivity in these communities. However, the limited amount of information available and our sketchy understanding of landscape function makes this threshold a tentative one. We need to further understand land use thresholds and the conditions under which they may vary.

## Finding the balance

Superficially, the concept that there is an upper limit to the amount of biophysical capital we can divert to human uses is not a controversial one. However, there is very little evidence that our society has really internalised and acted on this concept. We have reached the point where there is recognition of the need for native vegetation and wildlife, but in many cases there is no acknowledgment that, in the short term, this is a zero sum game. There is only a limited resource and some of it has to remain as biophysical capital. In Australia, there is a general call to find a balance between production and conservation, often expressed as 'sustainable development'. However, very few people or institutions are genuinely looking for, or even discussing what that balance might be. The search needs to be conducted at all scales relevant to land use planning, including farm, catchment, regional and national levels. An explicit dialogue about what the balance is would help to address inconsistencies between institutions in their approach to the use of exotic species and intensive land uses. It is hoped that by articulating the issues this paper can contribute to that discussion.

## Acknowledgements

The data presented in this paper were collected and analysed with the assistance of K. Best, T. Martin and C. Pernet and financial support from the Land and Water Resources Research and Development Corporation, and Meat and Livestock Australia (NAP3.222).

## References

Eyles, A.G., Cameron, D.G. & Hacker, J.B. 1985. *Pasture research in northern Australia - its history, achievements and future emphasis*. CSIRO Tropical Crops and Pastures, Brisbane.

Giampetro, M., Cerretelli, G. & Pimentel, D. 1992. Energy analysis of agricultural ecosystem management: human return and sustainability. *Agriculture, Ecosystems and Environment* 38:219-44.

Grice, A. C. & McIntyre, S. 1995. Speargrass (*Heteropogon contortus*) in Australia: dynamics of species and community. *Rangeland Journal* 17:3-25.

Henzell, E. F. 1968. Sources of nitrogen for Queensland pastures. *Tropical Grasslands* 2:1-17.

Landsberg, J. & Wylie, F. R. 1983. Water stress, leaf nutrients and defoliation: a model of dieback of rural eucalypts. *Australian Journal of Ecology* 8:27-41.

Landsberg, J. 1988. Dieback of rural trees in Australia. *GeoJournal* 17:231-7.

Landsberg, J. & Wylie, R. 1991. A review of rural dieback in Australia. *Growback '91*, pp. 3-11.

Lonsdale, W. M. 1994. Inviting trouble: introduced pasture species in northern Australia. *Australian Journal of Ecology* 19:345-54.

LWRRDC 1995. Data Sheets on Natural Resource Issues. Land and Water Resources Research and Development Corporation, Occasional Paper No. 06.

Martin, L. & Metcalfe, J. 1998. *Assessing the causes, impacts, costs and management of dryland salinity.* LWRRDC Occasional Publication No. 20/98.

McIntyre, S. 1993. The nature of exotic invasions in herbaceous vegetation of high and low species richness: implications for conservation and management. *10th Australian Weeds Conference and 14th Asian Pacific Weed Society Conference.* Brisbane, Australia, 6-10 September, 1993.

McIntyre, S. & Lavorel, S. 1994. Predicting richness of native, rare and exotic plants in response to habitat and disturbance variables across a variegated landscape. *Conservation Biology* 8:521-31.

McIntyre, S, McIvor, J. G & MacLeod, N. D. 1999. Principles for sustainable grazing in eucalypt woodlands: landscape-scale indicators and the search for thresholds. In: P. Hale, A. Petrie, D. Moloney & P. Sattler (eds) *Management for sustainable ecosystems*. Centre for Conservation Biology, University of Queensland; Brisbane, (in press).

McIvor, J. G., Noble, A. D. & Orr, D. M. 1996. *Stability and Productivity of Native Pastures Oversown with Tropical Legumes*. Meat Research Corporation, Sydney.

McIvor, J. G., Williams, J. & Gardener, C. J. 1995. Pasture management influences runoff and soil movement in the semi-arid tropics. *Australian Journal of Experimental Agriculture* 35: 55-65.

Noble, A. D., Cannon, M. & Muller, D. 1997. Evidence of accelerated soil acidification under Stylosanthes-dominated pastures. *Australian Journal of Soil Research* 35: 1309-22.

Noss, R. F. 1993. Sustainable forestry or sustainable forests? In: G. H. Aplet, N. Johnson, J. T. Olsen & V. A. Sample (eds) *Defining Sustainable Forestry*, pp. 17-43. Island Press, Washington, D. C.

Old, K. M., Kile, G.A. & Ohmart, C. P. (eds) 1981. *Eucalypt Dieback in Forests and Woodlands.* Proceedings of a Conference held at CSIRO Division of Forest Research, Canberra, 4-6 August 1980. CSIRO, Australia.

Pearson, S. M., Turner, M. G., Gardener, R. H. & O'Neill, R. V. 1996. An organism-based perspective of habitat fragmentation. In: *Biodiversity in Managed Landscapes: Theory and Practice*, pp. 77-95. Oxford University Press, New York.

Robinson, D. & Traill, B. J. 1996. Conserving Woodland Birds in the Wheat and Sheep belts of Southern Australia. Conservation Statement No. 10. Supplement to *Wingspan* 6. RAOU, Hawthorn East, Victoria.

Sattler, P. & Williams, R. 1999. *Conservation Status of Queensland's Bioregional Ecosystems.* Environmental Protection Agency, Queensland.

Thurow, T. L. 1991. Hydrology and erosion. In: R. K. Heitschmidt & J. W. Stut (eds) *Grazing Management An Ecological Perspective*, pp.141-59. Timber Press, Portland, Oregon.

Teitzel, J. K. 1992. Sustainable pasture systems in the humid tropics of Queensland. *Tropical Grasslands* 26:196-205.

Walker, B. & Weston, E. J. 1990. Pasture development in Queensland - A success story. *Tropical Grasslands* 24:257-68.

Walpole, S. C. 1999. Assessment of the economic and ecological impacts of remnant vegetation on pasture productivity. *Pacific Conservation Biology* 5: 28-35.

Weston, E. J., Harbison, J., Leslie, J. K., Rosenthal, J. K. & Mayer, R. J. 1981. *Assessment of the agricultural and pastoral potential of Queensland*. Agricultural Branch, Queensland Department of Primary Industries, Brisbane, Technical Report No. 27.

Williams, C. H. 1980. Soil acidification under clover pasture. *Australian Journal of Experimental Agriculture and Animal Husbandry* 20:561-67.

Wilson, B. (ed.) 1968. *Pasture improvement in Australia*. Murray, Sydney.

Wylie, F. R., Johnston, P. J. M. & Eisemann, R. L. 1993. *A Survey of Native Tree Dieback in Queensland*. Forest Research Institute Research Paper No. 16, Queensland Department of Primary Industries.

Woinarski, J. C. Z. 1993. Australian tropical savannas, their avifauna, conservation and threats. In: C. Catterall (ed.) *Birds and Their Habitats: Status and Conservation in Queensland*, pp. 45-63. The Queensland Ornithological Society, Brisbane.

# Perennial farming systems

E. C. Lefroy

Centre for Legumes in Mediterranean Agriculture
University of Western Australia
Nedlands WA 6907
elefroy@cyllene.uwa.edu.au.

It has been suggested that the only lasting solution to land degradation in Australia is to increase the proportion of perennial plants in the agricultural landscape. While this would involve radical change for Australian landholders, perennial farming systems themselves are not new. While most of the world's food is produced from monocultures of annual plants, the majority of the world's farmers grow their food in perennial polycultures. Shifting agriculture, home gardens and agroforests in the tropics and sub-tropics have long featured mixtures of annual and perennial plants. Two advantages of more complex mixed systems are better capture of resources and reduced risk of crop failure. More complete use of water and nutrients means less offsite effects such as pollution, eutrophication and salinity. But more effective resource capture generally comes at a price. It requires greater investment in permanent structure, especially roots, and strategies to secure nutrients and ward off pests. As a consequence, the downside of persistence is usually lower harvestable production. However, it is the exceptions to this general rule that give some cause for hope and demonstrate the value of experiment and the limits of theory. In the context of Australian agriculture, two major obstacles stand out: the generally low levels of plant production, ultimately dictated by our soils and climate; and the cost of the transition from annual to perennial based land use systems.

*Keywords: monocultures, persistence, polycultures, productivity, trade-offs*

## Introduction

In semi-arid climates, one way to reduce the risk of crop failure is to avoid the summer drought by matching short-lived annual crops to the length of the rainy season. The dryland monocultures that now typify modern agriculture originally evolved as a solution to this problem in the Middle East some eight to ten thousand years ago. This technological package, consisting of two grains (wheat and barley), three legumes (chickpeas, lentils and beans) and two grazing animals (sheep and goats) later spread to southern Europe. As it spread to central and northern Europe over several thousands of years it was adapted to the temperature constraints of higher latitudes. With the addition of several grains (oats and rye), two grazing animals (cattle and pigs), a few oilseed crops, and well adapted camp followers that we call weeds, this package has since been exported around the globe (Diamond 1997). Vast areas of forest, woodland and perennial grassland have been converted to synthetic annual grasslands of these crops with the spread of this technology. In few places, however, have the environmental consequences of its adoption been as swift and dramatic as those being experienced in Australia. The question is—can we develop productive farming systems that are better adapted to the Australian environment? This paper addresses that question by reviewing contributions to a workshop held, in Western Australia in September 1997, on developing agriculture as a mimic of natural ecosystems.

## Matching sources and sinks of water and nutrients

Most land degradation problems can be traced back to a mismatch of sources and sinks of water and nutrients in space and time. A mismatch occurs in space, for example, when shallow rooted crops and pastures cannot exploit otherwise scarce water and nutrients stored at depth. A classic mismatch in time occurs every summer in southern Australia when annual plants are not around to exploit two thirds of the available energy and up to one third of annual rainfall. Such imbalances are inherent in most high input annual systems and express themselves as erosion, eutrophication, soil acidity and soil and water pollution. The options are to change the management or change the structure of the farming system. In terms of management, Stirzaker (1999) claims that in irrigated horticulture where returns warrant large investment in environmental safeguards, the most sophisticated management in the world cannot overcome this fundamental problem.

Changing the structure means designing agricultural systems using plants that can capture water and nutrients when and where they are available. In principle, this could represent good commercial sense as well as environmental responsibility if the extra resources could be channelled into harvestable products. The experience of Ewel *et al*. (1991) in testing this idea is instructive. They established structural mimics of a successional rainforest community in Costa Rica as a permanent alternative to slash and burn farming. One mimic was made up of endemic plants, one of exotics, and one a mixture of the two. All were based on substitution of the life forms found in the natural succession—tree for tree, vine for vine, shrub for shrub. They then compared nutrient leaching in the three mimic systems with maize and cassava production. The mimics performed as well as natural succession in maintaining soil fertility, protecting against erosion and making full use of light, water and nutrients, but they concluded that lower yields are likely in such mimics as natural systems intrinsically feature a higher investment in structure.

Ong and Leakey (1999) also took a successional perspective in reviewing the lack of success of agroforestry in Africa as a response to declining soil fertility. They trace a shift in the attitudes of researchers from the initially naive expectation that complementary use of resources by trees and crops would be the norm, to the current view that competition rules. They suggest that competition is best avoided by selectively combining plants that are known to be strongly complementary in terms of their phenology (e.g. winter active with summer active), morphology (especially root architecture), and nutrient acquisition strategies. They also noted differences between the results of agroforestry research and ecological studies of savannah trees and understorey vegetation. While there is good evidence that the productivity of natural vegetation under savannah trees increases as rainfall decreases, it appears the opposite is true for agroforestry. They suggest we are seeing successional processes at work. The agroforestry experiments they studied typically featured young fast growing trees and exhibited a high degree of competition while mature savannah systems are characterised by a higher degree of complementarity. The basic problem this raises is that investment in woody plant structure requires time and effort, thereby reducing returns to farmers. They concluded that the greatest opportunity for agroforestry appears to be in filling niches in landscapes where resources are currently under-utilized by crops. In other words, imitate the large scale patch dynamics of savannah (or woodland) ecosystems, but avoid imitating natural systems at small scale as it comes with the penalty of competition in the early stages.

## Perennial plants in polyculture

Matching plants to resources will almost inevitably require land use systems composed of a mixture of species of various life forms. Given that each species in a mixture is likely to have to justify its inclusion on the basis of its direct commercial value, such farming systems need to be based on the multiple products of perennial polycultures. It is worth noting that there are probably more land use systems based on polycultures than on monocultures (Table 1), although the latter are more extensive and responsible for a higher proportion of the worlds food production. The point is that polycultures are not new, and as well as studying natural ecosystems, there is likely to be much to learn from traditional polycultures such as the first five types in Table 1, which are found in the tropics (Van Noordwijk & Ong 1999; Altieri 1992). The only land use system in Table 1 that does not exist yet is type 7, the subject of the research described by Jackson (1985), which is being developed as an alternative to type 11.

## Reducing risk through greater diversity

A claim often made for mixtures over monocultures is that they reduce the risk of crop failure. Trenbath (1999) looked at this question of diversity and stability from the farmers' perspective. In a review of multiple cropping systems in India, he observed that risk reduction comes at the cost of deferring short term production for longer term stability. Van Noordwijk and Ong (1999) add that the reason the debate on stability and complexity of natural and agroecosystems is so confused is that insufficient recognition has been given to the hierarchical nature of the systems considered.

Table 1. Land use types by life form, product and cultural system (Modified from Jackson 1985)

| Cultural type | Life forms | | Product | Land use system |
|---|---|---|---|---|
| 1. Polyculture | woody | perennial | fruit and seed | mixed orchards |
| 2. Polyculture | woody | perennial | vegetative | mixed woodlot |
| 3. Polyculture | woody | annual & perennial | fruit, seed and vegetative | alley cropping |
| 4. Polyculture | woody | annual & perennial | fruit, seed and vegetative | forest garden |
| 5. Polyculture | herbaceous | annual | fruit and seed | mixed cropping |
| 6. Polyculture | herbaceous | annual | vegetative | pasture |
| 7. Polyculture | herbaceous | perennial | fruit and seed | perennial grain crops |
| 8. Polyculture | herbaceous | perennial | vegetative | pasture |
| 9. Monoculture | woody | perennial | fruit and seed | orchard |
| 10. Monoculture | woody | perennial | vegetative | timber plantation |
| 11. Monoculture | herbaceous | annual | fruit and seed | cropping |
| 12. Monculture | herbaceous | annual | vegetative | silage |
| 13. Monoculture | herbaceous | perennial | fruit and seed | pasture seed crop |
| 14 Monoculture | herbaceous | perennial | vegetative | hay crops, grazing |

The implicit assumption is often made that stability at lower hierarchical levels is necessary before stability will accrue at higher levels. In fact, the reverse is equally likely. The question of whether diversity improves stability in food production, for instance, depends on the level at which the question is posed. For example, from the perspective of a grazing animal in a mixed plant community, a stable feed supply can be achieved from highly variable components, such as a grass-legume mixture in competitive balance for soil nitrogen. While the paddock as a whole and the cows intake may be stable, patches within it are fluctuating in a cyclical manner. At field level, farmers can achieve stable yields by inter-cropping different cultivars or crops, especially when the performance of the crops depends on external factors that cannot be predicted at the time of sowing. At farm level, a farmer can try to balance different field-level enterprises that are attractive but risky by maintaining a portfolio of complementary activities, e.g. a combination of market and subsistence-oriented activities. At the regional scale, stable urban food supplies can be achieved simply by linking very diverse and potentially risky specialised farming enterprises, leading to the paradox that the food choice in the 'developed' world is now more diverse than at any time in human history, while much of this is produced on farms which are less diverse than at any time before. The more specialised farms are exposed to substantial risks, but pay for protection by insurance schemes and social networks. In this sense, perennial agriculture is swimming against the tide of market forces that tend to drive farmers towards more specialisation and risk.

This question of scale emerges as a critical decision point for perennial farming systems as resource management and biodiversity conservation operate at larger scales than the economic decisions crucial to the survival of individual farmers, and are often in conflict with them. Main (1999) points out that the degree of diversity required depends entirely on the goals—restoration of ecosystem services, maintaining high yields, improving yield stability—and until the scale is specified and the goals at each scale made explicit, the question of diversity cannot be addressed.

## The downside: the trade-off between persistence and productivity

A trade off between persistence and productivity seems likely with perennial farming systems. Persistence will almost inevitably involve a greater investment in biological infrastructure, particularly woody above and below ground biomass, with a consequent decrease in harvestable product. Table 2 clearly illustrates this in the difference in net annual primary productivity between the pristine Banksia woodland and the annual crops. Despite the fact that the crops failed to capture two thirds of the annual rainfall, they consistently out-produce the native vegetation. The difference is largely due to the amount of investment the Banksia woodland has in below ground structure necessary to capture water and scarce nutrients. The point that Ong and

Leakey (1999) make about the place of agroforestry in exploiting resources unused by crops is supported by the performance of the Tagasaste plantation that has access to an elevated water table. Two of the contributors focused on the investment necessary in perennial structure for salinity management, and came to quite different conclusions. Hatton and Nulsen (1999) presented a case for woody perennials as the only plants capable of maintaining permanent leaf area over a sufficient proportion of the landscape. Dunin *et al*. (1999) presented results of phase farming experiments on the riverine plains of New South Wales, suggesting herbaceous perennials like Lucerne could be sufficient when used in rotation with crops. Ewel (1999), Neher (1999) and Grierson and Adams (1999) all point out that the high investment in nutrient acquisition and cycling strategies mediated by soil biota, and important to the persistence of natural ecosystems, are likely to be switched off by additions of fertiliser if more complex perennial systems are 'pushed' towards higher production.

Joffre *et al*. (1999) described the oldest continuous farming system in Europe, the cork oak dehesa of southern Spain and Portugal. They suggested ecological sustainability and persistence have been achieved at the cost of suboptimal productivity and social inequity, the latter as it has relied heavily on poorly rewarded labour for its maintenance.

The dissenting voices on the subject of trade-offs, and therefore the most encouraging, were Jackson and Jackson (in press). Their work demonstrating that perenniality and high seed yield are not mutually exclusive trade-offs in the perennial Gama Grass (*Tripsacum dactyloides*) is an exciting finding that opens the door to the prospect of perennial grain agriculture. Whether their example has general applicability to other species and life forms remains to be tested.

## The limits of theory

If long term persistence and yield stability are likely to come at the cost of short term productivity, how can perennial farming systems ever be sufficiently attractive to be adopted by farmers? That question may well highlight the limits of theory in resolving the problem of agriculture. Many contributors conclude their analysis with fairly pessimistic prognoses, particularly in terms of the trade-offs that are likely and the complexities of management. And yet the two contributions that are based on the experience of constructing and testing novel systems offer a more optimistic prognosis. Jackson and Jackson (in press), in demonstrating that high seed yield and persistence are not mutually exclusive, offer the specific hope for perennial grain

Table 2. Above ground net annual primary productivity of annual crops and pastures, Rhodes Grass (*Chloris gayana*), a plantation of the fodder shrub Tagasaste (*Chamaecytisus proliferus*), and Banksia woodland at Moora, Western Australia. (Source: Pate & Bell 1999; Lefroy & Pate, unpubl. data).

| Plant community | Annual productivity (t $ha^{-1}$) | Biomass per unit rainfall (kg $mm^{-1}$) |
|---|---|---|
| Banksia woodland (1995-1997) | | |
| Pristine | 2.4 | 4.5 |
| At agricultural interface (elevated water table and N) | 8.4 | (15.9) |
| Annual crops and pastures[1] | | |
| wheat | 2.8 - 6.8 | 4.0 - 17.0 |
| lupins | 4.2 - 6.5 | 9.2 - 18.0 |
| sub-clover based pasture | 3.4 - 7.6 | 7.8 - 11.4 |
| Perennial pasture | | |
| Rhodes Grass | 1.9 | 4.6 |
| Tagasaste plantation | | |
| 1996 (1st year re-growth) | 4.4 | (10.0) |
| 1997 (2nd year re-growth) | 20.1 | (48.7) |

1 Range covers 1994 to 1997 with annual rainfall of 294, 703, 438 and 412 mm respectively, numbers in brackets are for plant communities with access to perched water table.

agriculture despite theory to the contrary. Ewel and colleagues (1991) demonstrated that with carefully chosen but taxonomically very simple mimics, ecological targets based on the water and nutrient cycling of a complex rainforest community can be successfully met. This opens the way for land use systems based on species of high commercial value that meet the same criteria of structure and function.

The caution of many of the other contributors comes largely from their observation that there will be great difficulty in developing perennial farming systems to the point that they are manageable and can profitably compete with current practice. This difficulty is represented by the last step in the sequence below from Dawson and Fry (1998) on stages in the development of sustainable farming systems:

1. Perception of the problems and the need for fundamental change, specifically identification of the ecosystem functions sub-optimal in the current managed systems.
2. Analysis of the form and function of natural ecosystems, particularly information on below ground plant architecture and activity, in order to identify key functions and functional groups in natural and managed ecosystems.
3. Developing commercial crops from functional analogues—this means extending the range of conventional bio-prospecting to include consideration of the functional role of economic species in managed landscapes. As mimicking processes at the landscape scale inevitably means a mosaic in time and space, there can, by definition, be no 'silver bullet' solutions in the form of one or two new crops as the dominant species.
4. Identifying whether it is most appropriate to integrate or segregate these functions with production at field and landscape scales. This may rule out ecosystem mimicry at the field scale due to the costs of competition for resources between species in polycultures. Where the cost of that competition is greater than the benefits of added ecosystem services or biodiversity conservation, the segregation of roles (production versus resource and/or biodiversity conservation) would be the better option.
5. Acknowledging people as part of the landscape and developing strategies to overcoming the obstacles facing adoption, particularly the profitability of alternatives relative to current practice and the feasibility of testing them.

## Adaptive management

Despite the amount of effort put into steps 1 to 4, if the last condition is not met little is achieved in practice. And yet to be overwhelmed by the last step may well be to give up before starting. An example of changing land use systems in south western Australia may serve to illustrate this point. Over the last decade, the Tasmanian Blue Gum (*Eucalyptus globulus*) has been introduced into the higher rainfall areas (> 600 mm $y^{-1}$) as an alternative to meat, wool and milk production from farming systems based on annual plants. Harvested on rotation for fibre and sawn timber, it represents an alternative source of income. As a summer active perennial, it represents an opportunity to address the imbalance in the hydrological cycle that is a feature of annual based farming systems in this region. Catchments that now include plantings of Blue Gums, either segregated or integrated with conventional farming, cannot be considered as mimicking the original vegetation, but could be regarded as a first step in that direction. In hindsight, this process can be seen as having fast tracked the above steps, with 1, 3 and 5 considered and steps 2, and 4 overlooked. The key to this alternative landuse becoming a viable option for farmers came with step 5; specifically a share farming scheme that now sees government, and increasingly private enterprise, in partnership with landowners. The landowner is paid an annuity based on the projected value of the trees at harvest, while the partner bears the cost of establishment and harvest and shares the risks. There is also the prospect of longer term benefits through carbon trading.

This is not to suggest that Blue Gum agroforestry represents a mimic of the Jarrah forest. There are many issues to be addressed such as: the appropriateness of site and species selection in the face of tree deaths; vulnerability to disease; the minimal level of functional diversity; and the social protest that is occurring over the ecological and aesthetic impacts of a short term panacea based on monoculture. The point of this example, however, is that out of this may well evolve a more sustainable and commercially viable form of land use that may not have happened by simply progressing through the above steps in sequence, and certainly would not have happened without the intervention of step 5, the share farming scheme. In other words, solutions to complex problems at landscape scales are not going to be developed in the form of new, complete technological packages, but are more likely to evolve through a process of adaptive management (Holling

1978; Walters 1986)—learning by experiment and attending to the finer details once some momentum has been established.

The primary reason for interest in perennial farming systems in southern Australia is to develop crop and pasture production systems more closely tailored to the unique characteristics of Australia's climate and soils. The fact that very few new food plants have been domesticated in the last few centuries emphasises the challenge involved in identifying and domesticating new species. Finding alternatives to the wheat that occupies 15 million hectares of Australia is not a realistic option. Rather than find a substitute for annual crops, the approach suggested by the mimic concept would be to return deep-rooted summer active species to the agricultural landscape in roughly the same proportions that existed prior to clearing. If the natural ecosystem is a good indicator of what is required to restore ecosystem processes, it is then up to the ingenuity of the designers, farmers, foresters, ecologists and agronomists to find commercially attractive products within those life form and functional constraints.

## Acknowledgements

The workshop 'Agriculture as a Mimic of Natural Ecosystems' was made possible by grants from the Rural Industries Research and Development Corporation, the Meat Research Corporation, the Land and Water Resources Research and Development Corporation, and The University of Western Australia. This paper is based on a summary of that workshop published as Lefroy *et al*. (1999).

## References

Altieri, M. A. 1995. *Agroecology* (2nd ed.) Westview, Boulder.

Berry, W. 1977. *The Unsettling of America: Culture and Agriculture*. Sierra Club Books.

Dawson, T. E. & Fry, R. 1998. Agriculture in Nature's Image. *Trends in Ecology and Evolution* 13(2): 50-1

Diamond, J. 1997. *Guns, Germs and Steel*. Jonathan Cape, London.

Dunnin, F. X., Williams, J., Verburg, K. & Keating, B. A. 1999. Can agricultural management emulate natural ecosystems in recharge control in south eastern Australia? *Agroforestry Systems* 45: 343-64.

Ewel, J. J., Mazzarino M.J. & Berish C.W. 1991. Tropical soil fertility changes under monocultures and successional communities of different structure. *Ecological Applications* 1:289-302.

Ewel, J. J. 1999. Natural systems as models for the design of sustainable systems of land use. *Agroforestry Systems* 45: 1-21.

Grierson, P .F. & Adams, M. A. 1999. Nutrient cycling and growth in forest ecosystems of south western Australia: application to agricultural landscapes. *Agroforestry Systems* 45: 215-44.

Hatton, T. J. & Nulsen, R. A. 1999. Towards achieving functional ecosystem mimicry with respect to water cycling in southern Australian agriculture. *Agroforestry Systems* 45: 203-14.

Holling, C. S. 1978. *Adaptive Environmental Assessment and Management*. John Wiley and Sons, Chichester.

Jackson, W. 1985. *New Roots for Agriculture*. University of Nebraska Press, Nebraska.

Jackson, W. & Jackson, L. (in press). Developing high seed-yielding perennial polycultures as a mimic of mid-grass prairie. In: E. C. Lefroy, R. J. Hobbs, M. H. O'Connor & J. S. Pate (eds) *Agriculture as a Mimic of Natural Ecosystems*. Kluwer, Dordrecht, The Netherlands.

Jackson, W. & Piper, J. 1989. The necessary marriage between ecology and agriculture. *Ecology* 70: 1591-3

Joffre, R., Rambal, S. & Ratte, J.P. 1999. The dehesa system of southern Spain and Portugal as a natural ecosystem mimic. *Agroforestry Systems* 45: 57-79.

Lefroy, E. C., Hobbs, R. J., O'Connor, M. H. & Pate, J. S. 1999. What can agriculture learn from natural ecosystems? *Agroforestry Systems* 45: 423-36.

Main, A. R. 1999. How much biodiversity is enough? *Agroforestry Systems* 45: 23-41.

Neher, D. A. 1999. The role of soil community composition in ecosystem processes: Comparing agricultural and natural ecosystems. *Agroforestry Systems* 45: 159-185.

Ong, C. K. & Leakey, R. R. B. 1999. Why tree-crop interactions in agroforestry seem at odds with tree-grass interactions in tropical savannahs. *Agroforestry Systems* 45: 109-29.

Pate, J. S. & Bell, T. L. 1999. Application of the ecosystem mimic concept to the Banksia woodlands of south western Australia. *Agroforestry Systems* 45: 303-41.

Stirzaker, R. J. 1999. The problem of irrigated horticulture: matching the biophysical efficiency with the economic efficiency. *Agroforestry Systems* 45: 187-202.

Trenbath, B. R. 1999. Multispecies cropping systems in Central India: predicting productivity, stability, resilience, and ecological sustainability. *Agroforestry Systems* 45: 81-107.

Van Noordwijk, M. & Ong, C. K. 1999. Can the ecosystem mimic hypotheses be applied to farms in African savannahs? *Agroforestry Systems* 45: 131-158.

Walters, C. 1986. *Adaptive Management of Renewable Resources*. Macmillan, New York.

# Maintaining tree cover health in temperate pastoral landscapes

Nick Reid

Ecosystem Management
School of Rural Science and Natural Resources
University of New England, Armidale NSW 2351
nrei3@metz.une.edu.au

Scattered native trees and stands of trees (predominantly eucalypts) occur across 45% of the farmland in temperate Australia, and have a replacement value of at least $20 billion. Remnant farm trees are threatened by clearing, lack of recruitment and rural dieback in many areas. This paper reviews information concerning the maintenance of tree cover health where lack of regeneration and dieback are major problems. Dieback is the widespread premature death or debility of trees. It has various causes, but the most pervasive in the higher rainfall districts in eastern Australia is chronic insect attack. Eucalypt-feeding scarab beetles, particularly Christmas beetles, are a major cause of New England dieback. The larvae feed on pasture roots and soil organic matter and are most abundant in sown fertilised pastures away from trees. The natural predators of scarab larvae include wasps and parasitic flies, as well as large birds such as ibis and magpies. In New England, the extent and intensity of eucalypt dieback is regulated by climate and the extent of pasture intensification and corresponding reduction in tree numbers and native understorey. Suggested 'dieback-proofing' strategies include: (1) maintaining or developing ungrazed networks of trees, flowering shrubs and forbs at no greater than 400 m intervals across farms and catchments; (2) avoiding fertiliser applications in the vicinity of trees; (3) restricting the development of high-input pastures; and (4) locating high-input pastures well away from remnant trees and vegetation.

*Keywords: biological control agents, Christmas beetles, defoliating insects, dieback, insectivorous birds, native pastures, parasitoids, pasture scarabs, sown pastures, tree health*

## Introduction

Native trees (predominantly eucalypts) are a distinctive feature of temperate farming landscapes in southern Australia. Reid and Landsberg (1999) estimated that scattered trees (5-10% cover) and stands (>10% cover) occupied 20 and 7 million ha, respectively, or 45% of the temperate agricultural districts. The replacement cost of these trees is of the order of $20 billion (using the tree planting costs in Wilson *et al.* 1995). Native trees in the agricultural landscape have considerable value from several points of view: they provide direct and indirect economic benefits to primary producers, contribute to real estate values in some districts, and provide a range of ecosystem services to society, which are difficult to value (Reid & Landsberg 1999). Examples include maintenance of healthy catchments through mitigating or preventing land degradation, enhancement of catchment water quality in riparian zones, and conservation of biodiversity.

Persistence of farm trees is threatened by three main processes (broadacre clearing, lack of regeneration, rural dieback) and numbers are diminishing through time in most of the higher rainfall zone in southern Australia (Reid & Landsberg 1999). Broadacre clearance for agriculture has been the single most important cause of farm tree loss in temperate Australia, and continues to varying degrees in most states. Lack of recruitment of farm trees is a second reason for the continuing decline, as old senescent trees are not replaced by young trees. Cultivation, competition with fertilised pastures, and heavy sheep grazing, alone or in concert, suppress eucalypt regeneration. The reasons for and solutions to tree clearing and lack of natural regeneration are well understood and, in theory, are readily soluble other than for the barriers of ignorance or lack of political will (Whalley & Curtis 1991; Farrier 1995; Prescott 1996; Reid & Landsberg 1999). Rural dieback, on the other hand, is not well understood and is not being managed. Dieback is the premature decline and death of rural trees. Dieback results from a variety of causes in different districts, e.g. dryland salinity (Wylie & Bevege 1981; George *et al.* 1996), *Phytophthora cinnamomi* (Podger *et al.* 1996), over-browsing by Common Brushtail Possums (*Trichosurus vulpecula*) (Loyn & Middleton 1981), lack of water reaching River Redgums (*Eucalyptus camaldulensis*) in floodplain environments (Bacon 1996), exclusion of insectivorous birds from eucalypt stands by Noisy Miners (*Manorina melanocephala*) (Clarke *et al.* 1995), and excessive defoliation by insects (Mackay *et al.* 1984; Landsberg & Wylie 1988, 1991; Wylie *et al.* 1993).

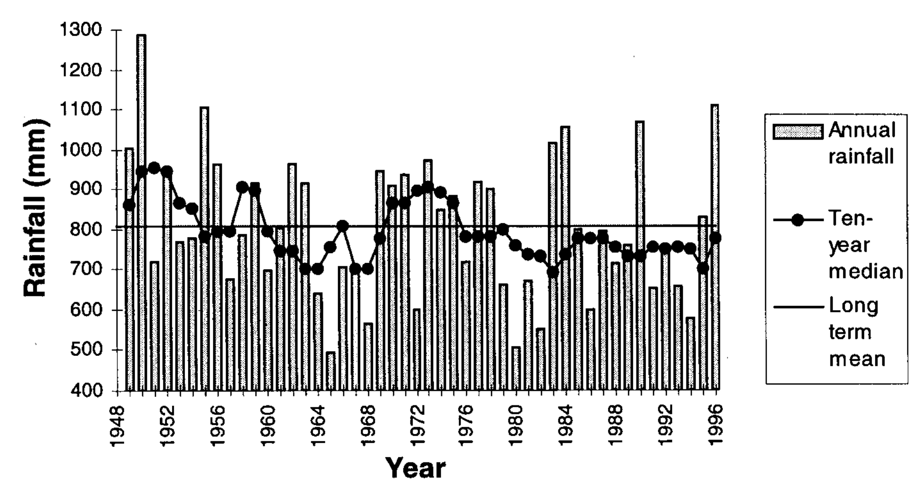
Insect-mediated dieback appears to be the most frequent type of rural dieback in mainland eastern Australia. Because the problem is now widespread in rural districts and new occurrences are continually being reported, dieback has the potential to threaten not only existing farm trees in the agricultural matrix, but also the viability of the nation's multi-billion dollar investment in rural revegetation. Accordingly, this paper sets out to: (1) summarise knowledge of insect-mediated dieback of farm eucalypts; (2) profile two graziers' experiences with the biological control of defoliating insects by encouraging the natural predators and parasitoids of defoliating insects on-farm; and (3) suggest a set of 'best-bet' strategies that farmers might contemplate in order to 'dieback-proof' their properties.

## Insect-mediated dieback: correlates with the biophysical environment and land use

Several observations about the extent and severity of insect-mediated dieback are relevant from a management viewpoint. First, dieback is closely associated with runs of years of unusual rainfall on the Northern Tablelands of NSW (White 1986). Over the past 50 years, the 10-year running median of annual rainfall has only exceeded the long-term mean on two occasions, over several years each in the early 1950s and 1970s (Fig. 1). Both runs of years of high rainfall coincided with the worst insect defoliation and dieback on the Tablelands (White 1986). In a survey of 192 paddocks on 19 properties between Armidale and Walcha, NSW, Jones *et al.* (1990) found that the percentage of tree crowns suffering from dieback near Armidale varied from 41% in 1970 to 58% in 1980, and down to 36% by 1986.

Second, dieback is associated with decreasing tree cover at a paddock scale. Jones *et al.* (1990) found that the percentage of trees affected by dieback in 1980 increased with decreasing

Figure 1. Annual rainfall at the CSIRO Pastoral Research Laboratory, 'Chiswick', on the Northern Tablelands of NSW, 1949-1996. Source: K. Hutchinson (pers. comm.).



percentage of paddock that was wooded (of any health), decreasing quantity of live tree basal area, and decreasing percentage of paddock covered by live and healthy trees. Wylie *et al.* (1993) surveyed 171 property owners in southern and central Queensland and northern NSW between 1981 and 1983, and found a marginally significant correlation between increasing dieback severity and increasing loss of tree cover at a property scale. Dieback was least severe on properties with large areas (> 10 000 ha) of remnant tree cover and most severe on properties with least tree cover (< 10 ha). Timing of clearing was also important. Dieback was more severe on properties where clearing had commenced more than 50 years ago than on properties where clearing commenced more recently.

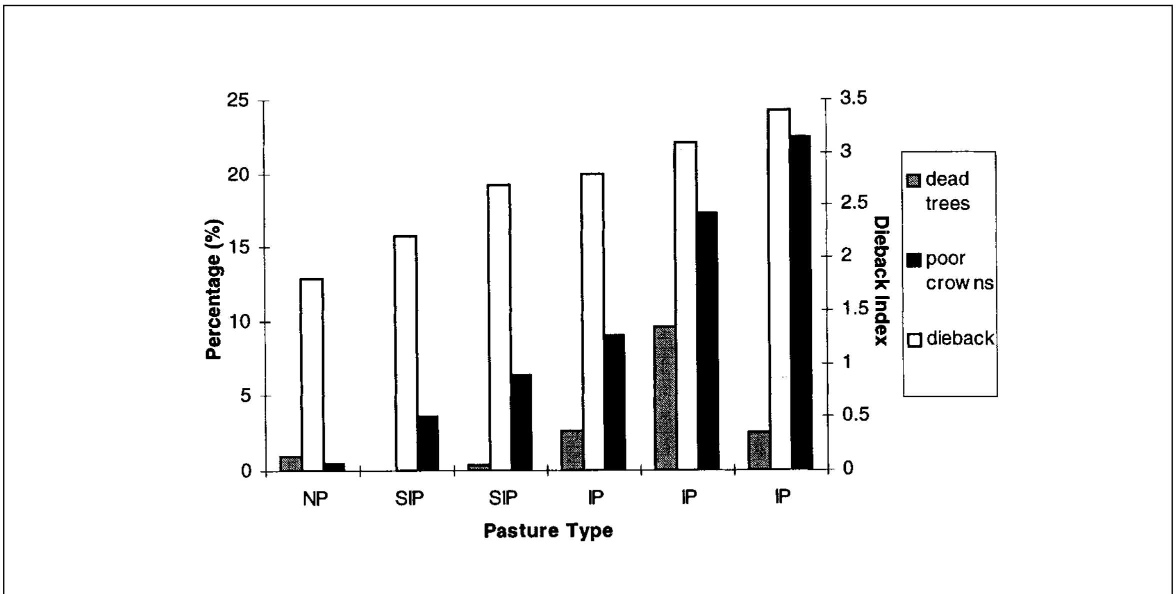
Third, dieback is associated with the extent of land use intensification and improved (sown) pasture in pastoral districts. Wylie *et al.* (1993) showed marked increases in the severity of dieback in their 1981-83 survey on properties with > 50% of the property under improved pasture, and on properties that used fertiliser compared to properties that did not. Similarly, Duggin (1981) showed that, in the Armidale area, three different indices of dieback registered most dieback in three land systems dominated by improved pastures, least dieback in the land system dominated by native pastures, and intermediate levels of dieback in two land systems with intermediate levels of sown or semi-improved pasture development (Fig. 2). Sinden *et al.* (1983) found that increases in dieback and decreases in live tree cover were correlated with increased stocking rate in, and increased land values of, densely-wooded paddocks in southern New England.

Fourth, absence of shrub layer is significantly associated with dieback. Jones *et al.* (1990) showed, in the southern New England paddock survey, that dieback was less severe when a shrub layer was present.

Fifth, dieback is most severe on plains and valley floors. Jones *et al.* (1990) found that dieback severity decreased as slope increased in their southern New England survey. Wylie *et al.* (1993) found more severe dieback on flat lands and undulating plains of low to moderate relief than in hilly or mountainous country in south-central Queensland and northern NSW. The association between dieback and flat land may be due to one of two reasons: land use intensification (cultivation, clearing) is generally greatest in such areas; or, alternatively, such sites are poorly drained so trees in such sites are subject to greater waterlogging in wet periods and less water stress in dry periods.

Finally, tree species show generally consistent patterns of susceptibility to dieback within and

Figure 2. The severity of dieback in six land systems dominated by native pasture (NP), semi-improved pasture (SIP) and improved pasture (IP) in the Armidale region. Dieback was measured as the percentage of trees dead, the percentage of trees with poor crowns (and likely to do within a year), and mean dieback index (from 0 [healthy] - 5 [dead]) in each land system. Source: Duggin (1981).



between regions, which may be largely related to topographic position in the landscape. On the Northern Tablelands of NSW, New England Peppermint (*Eucalyptus nova-anglica*) has always been more susceptible to dieback than other species (Norton 1886; Duggin 1981; Williams & Nadolny 1981; Sinden *et al.* 1983; Mackay *et al.* 1984; Lowman & Heatwole 1992). Its habitat is valley floors and lower slopes on metasedimentary and granitic parent materials. Blakely's Red Gum (*E. blakelyi*) replaces it in lower to mid-slope positions, and is next most susceptible. On the Southern Tablelands of NSW, Blakely's Red Gum is the valley floor specialist and is most severely affected in that region (Landsberg 1988).

## A model of insect-mediated dieback

Many kinds of insects defoliate or otherwise damage the foliage of farmland eucalypts (Elliott *et al.* 1998), including tree-feeding scarab beetles, chrysomelid leaf beetles, sawflies (*Perga* spp.), lerp, autumn gum moth (*Mnesampela privata*) and cup moth (*Doratifera* spp.) in the New England region (Duggin 1981; Ford 1981; Lowman & Heatwole 1992). Most insect defoliation of farm trees in eastern Australia occurs across the summer from spring to autumn (Lowman & Heatwole 1992). However, some defoliating insects are active in winter. This defoliation between autumn and spring may be crucial in leading to tree death by removing the autumn flush of new growth in eucalypts.

Although many different types of insect damage the foliage of farmland eucalypts, the most important defoliating insects on the tablelands of NSW in relation to dieback are the pasture scarabs (Mackay 1978). Several considerations point to this conclusion. The worst periods of dieback on the Northern Tablelands in the 1950s and 1970s were associated with repeated outbreaks of adult pasture scarabs in summer (November to February). Larval scarabs are abundant and diverse in pasture soils in the higher rainfall districts of eastern Australia. Over 40 species occur on the Northern Tablelands (Davidson 1984). Not all are tree foliage feeders as adults, but tree-feeding species dominate the pasture biomass of larval scarabs up to 1200 m from trees (Roberts *et al.* 1982). Pasture scarab larvae are more abundant in open pasture than woodland, and in sown fertilised pasture than native pasture (by 2-3 times) (Davidson *et al.* 1979; Campbell & Brown 1995). Scarab abundance is controlled by climate (Carne *et al.* 1981): waterlogging results in high larval mortality, as does summer drought through high soil temperatures and desiccation. Moreover, adult scarabs do not emerge from pupae in the soil in the absence of rain, and gravid females require moist soil for burrowing. Presumably, rainfall in the early 1950s and 1970s was ideal for scarabs (and pasture and livestock production) in providing sufficient regular rainfall throughout the year to maintain moist, but not waterlogged, soils.

Tree-feeding adult scarabs are only active between November and February (Davidson 1982). In outbreak years, however, adult scarabs are sufficiently abundant to strip all the foliage of eucalypts, forcing the trees to resprout epicormically. Epicormic growth is more nutritious than mature foliage (Landsberg 1990a,b), enabling flush feeding insects that normally confine themselves to new growth to re-defoliate resprouting trees. Thus, if climatic conditions are appropriate and natural control agents absent, a succession of other insects can strip resprouting trees—chrysomelids in late summer-autumn, cup and gum moth larvae in autumn-winter and sawfly larvae in winter-spring (Reid & Landsberg 1999). If this cycle is maintained over successive years, the trees' energy reserves are depleted and the trees die (Mackay *et al.* 1984).

The role of soil fertility and pasture 'improvement' requires comment. Sown fertilised pastures are more productive than unfertilised native or naturalised pastures. Published data indicate a larval scarab biomass up to 400 kg/ha in phalaris-white clover pastures (Hutchinson & King 1980), though liveweights of 5 t/ha have been reported (A.J. Campbell, pers. comm., August 1999). Scarab larvae feed on the microflora associated with plant roots and may ingest plant roots in the process. Scarab production increases with sown pasture development due to the inputs of fertiliser and the replacement of $C_4$ grasses by more palatable $C_3$ grasses and clovers. Scarab biomass is greatest at intermediate stocking rates when net primary production is maximised (Hutchinson & King 1980). Scarab biomass is reduced at low and high stocking rates due to reduced primary production and the aversion of female scarabs for rank ungrazed pasture for oviposition at low stocking rates, and the inhospitable soil environment in overgrazed pastures (Roberts 1979; Hutchinson 1997). Pasture improvement (and nutrient input associated with sheep camps) also enhances the nutrient status of the foliage of trees in sown fertilised pastures, making trees more attractive to leaf-feeding insects (Reid & Landsberg 1999).

Interestingly, many of the factors that regulate pasture scarab abundance affect other major groups of defoliating insects in similar ways. Droughts in spring and early summer lead to high mortality through desiccation of the late larval stages of eucalypt-defoliating sawflies (*Perga affinis*), and to the inhibition of the production of the age class of leaves required by adults for oviposition in autumn (Carne *et al.* 1981). Hot dry summers or very wet summers also lead to high mortality of the pre-pupal stages in the soil. In the case of chrysomelid leaf beetles, survival and growth are determined by temperature, humidity and foliage quality (Ohmart & Edwards 1991).

A final consideration in insect-mediated dieback in eastern Australia is the inefficacy of natural biocontrol agents in controlling defoliating insect abundance on farms. The literature records tiphiid and scoliid wasps, tachinid flies, birds and sugar gliders as natural control agents of scarab larvae and adult beetles (Campbell & Brown 1985; Smith 1995). Davidson (1982) argued that the loss of habitat of natural biocontrol agents close to commercially grazed pastures had led to a reduction in natural biocontrol agents on farms, and therefore to an increased abundance of insect pests in their absence. He recommended that graziers be encouraged to provide habitat for parasitoid wasps, parasitoid and predatory flies, predatory beetles, spiders, insectivorous birds, and other vertebrate and invertebrate predators and parasitoids, to help reverse dieback.

## Biological control of dieback

Campbell & Brown (1995) studied the interactions between native parasitoids and scarab beetles at the interface between pasture and native vegetation on two grazing properties and adjacent public land east of Armidale. Their 3-year study coincided with the 1994 drought. Over 31,000 specimens of 54 species of tiphiid, 23 tachinids, 3 scoliids and at least 30 scarabs were collected, but no confirmed records of parasitism of scarabs were obtained. Circumstantial evidence pointed to the parasitism of one woodland species of Rhopaea by a tiphiid wasp. On the other hand, observations suggested that nematodes and birds (magpies, currawongs, ibis and ravens) had most impact on larval densities in the pasture in damp spots favoured by larvae. Soil fungi and Echidna were also implicated in control. The study clarified the habitat requirements of the potential insect biocontrol agents. Both the adult flies and wasps depend for energy on a wide variety of flowering shrub genera (e.g. *Callistemon*, *Leptospermum*, *Baeckea*, *Bursaria*, *Dodonaea*, *Lissanthe*, *Melichrus*) and forbs (*Pimelea*, *Ammobium*) as well as farm trees and honeydew exuded by sap-sucking insects (e.g. homopterans).

## Grazier profile no. 1: Bob Waugh, 'Bergen op Zoom', Walcha, NSW

Bob Waugh and Cat MacGregor own and manage the 2,100 acre (850 ha) property 'Bergen op Zoom', just outside Walcha on the Northern Tablelands of New South Wales. The property runs fine-wool Merino sheep and beef cattle on semi-improved pastures. Much of the property was sown to pasture in the 1960s and 1970s, but only three applications of superphosphate (125 kg/ha) have been applied in the past 20 years. The original timber on the low lying fertile plains and slopes was dominated by New England Peppermint (*Eucalyptus nova-anglica*), a eucalypt endemic to the Northern Tablelands. The New England Peppermint grows in the lowest, most fertile parts of the landscape and relies on growing more leaf after defoliation rather than inherent chemical resistance.

The property was settled in the 1840s and was still heavily timbered in 1915 (old photographs), but much of what remained by the 1980s were exotic trees. Most of the stands of native timber on the property died in the 1960s and 1970s during the worst of the New England dieback. Interestingly, young stands of peppermint recruited on the neighbouring property at this time apparently because the neighbours were running cattle but not sheep.

Because of his love of New England Peppermints and the threat posed to remaining stands by clearing and insect (Christmas beetle) defoliation, Bob chose to revegetate the property with 3 km of Peppermint and Black Sally (*Eucalyptus stellulata*) shelterbelts in 1988. In their second growing season, the young Peppermints were defoliated by Christmas beetles, followed by autumn gum moth larvae when many trees had grown to 2 m in height. Bob decided to spray all the trees with a broad-spectrum insecticide. In the third growing season, the defoliation recurred and he turned his back on the trees in despair. By the fourth growing season, Bob had done some research and obtained quantities of commercially available eggs of two biocontrol agents, a trichogrammatid wasp and lacewings (*Neuroptera*). Interestingly, however, only a small number of hotspots of defoliated trees appeared. The eggs of the biocontrol agents were duly deployed around the windbreaks and, sure enough, Bob found a lot of the gum moth eggs parasitised in the fourth season. However, the trichogrammatid wasp wasn't the control agent. A local scoliid wasp (a specialist egg predator) emerged from 80% of the autumn gum moth eggs. When he stopped and thought about it, Bob realised that the defoliation hadn't been as intense in the previous season as the second season. He had noticed that where the windbreaks ran past remnant mature peppermints, the defoliation hadn't been as severe.

In the fourth season, soon after gathering up the gum moth eggs for analysis, he started to find the desiccated carcasses of large gum moth caterpillars in the windbreaks. Observation revealed that another biocontrol agent, a pentatomid shield bug was responsible. The bug has four instars before becoming a flying adult. He found up to 14 first instar larvae attached to caterpillars, sucking larval innards. The bug was not abundant, but they ate a lot of caterpillars. One third instar larva took only 7 hours to consume a large caterpillar.

Further observation revealed more biocontrol agents at work in the windbreaks. Two wasps, a braconid and an unidentified wasp, were noticed ovipositing in caterpillars. The caterpillars kept growing after being parasitised despite the growing larvae within, but ultimately all the wasp larvae erupted from the burst caterpillar to pupate.

So, in summary, three main biocontrol agents (the scoliid and braconid wasps and pentatomid bug) had a major impact on gum moth larvae in the ungrazed windbreaks by the fourth season, and it was evident that this level of control had built up over 2 years. In retrospect, Bob wonders whether he didn't delay development of the efficacy of the natural control agents with his use of broad-spectrum insecticide in the second season. Other control agents were also at work in the windbreaks by this time. Spiders and frogs were observed predating gum moth larvae.

Over the period of these observations, autumn gum moth and cup moth larvae were more damaging to the Peppermints than scarabs because they entirely defoliated young trees. Christmas beetles, though present, were not as damaging, only resulting in partial defoliation of Peppermints. The moths, on the other hand, did not touch the Black Sallee, although Christmas beetles did. Despite the control exerted by the parasitoids, the repeated defoliation had lasting effects on the form of the trees, with many trees stunted, twisted and under-sized.

Another interesting observation made in the homestead garden was the different flower preferences exhibited by parasitic wasps and honeybees. For instance, goldenrods (*Solidago* spp.) were favoured by the adult parasitoids but avoided by honeybees. This led Bob to plant a range of forbs as nectar sources in the ungrazed windbreaks to encourage the adult wasps.

### Grazier profile no. 2, Richard Weatherly, 'Connewarran', Mortlake Vic. (Weatherly 1997)

'Connewarran' is a 4000 acre (1600 ha) grazing property in 530 mm (21 inch) annual rainfall country, 50 km from the sea, in western Victoria. Richard direct-seeded his first native trees on his family's property in 1964, and started sowing understorey in 1976. He now has between 8-12% of the property under direct-seeded native trees and shrubs, as corridors and shelterbelts of woody vegetation along paddock boundaries linking larger ecosystem nodes of planted woody vegetation over 100 m wide. This represents a considerable investment in biodiversity in today's contract planting prices. The property is well-wooded on the ground, with trees and shelterbelts in every direction, but Richard aims to keep revegetating and to double the area under woody vegetation. About 60 ha of the property is wetland, and 50 ha is native pasture grazed only between February and June to preserve the diversity of flowering forbs and grasses. Recently, 40% of the property has been developed for raised bed cropping (canola, red wheat, barley, lentils) as a cost-effective means of raising core fertility of the less productive paddocks.

Richard's main farm enterprise is Merino wool (19.5-20.5 micron). He invested in sown pastures, having inherited a native pasture base in the 1960s. He fertilises the sown pastures annually with 15-30 kg phosphorus/ha (equivalent to 150-300 kg/ha of single superphosphate), and he aims for paddock soil to average 10.5-12.0 ppm available (Olsen) P. Although he acknowledges that higher fertility is bound to exacerbate pasture scarab densities, and therefore potential eucalypt defoliation, he believes he has achieved an appropriate balance between farm insect pests and their control through the farm ecosystem.

Richard's primary motivation for revegetating the property has been to increase productivity of the agricultural operation through shade and shelter. His second reason has been to preserve landscape function, biodiversity and aesthetics by maintaining interactions between the indigenous and agricultural systems and encouraging mobility of fauna. Concern about bushfire ranks a distant third.

Richard has developed four principles of revegetation in relation to encouraging the biological control of pest insects (e.g. tree defoliators and pasture pests, blowflies and bush flies) in the farm ecosystem:

1. He has planted over 130 different species of tree, shrub and herb. While his diverse mixtures of trees, shrubs and herbs might appear random, they are not. Species and genera are selected on the basis of flower shape or other attractants for specific arthropod predators and parasitoids of particular pests, and for birds.
2. He prefers not to be limited in the geographical provenance of Australian native plants grown, striving for natives that grow well and provide a broad diversity of floral types and flowering seasons in intermixed vegetation stands. He is not restricted to the germplasm of the few native tree and shrub species that remained on the property in the 1960s. For instance, the Silverton provenance of River Red Gum (*Eucalyptus camaldulensis*) and one East Gippsland provenance of Blackwood (*Acacia melanoxylon*) perform better than either local provenance at 'Connewarran'. He is not adverse to exotics either. He cites the nesting preference shown by Brown Goshawks (*Accipiter fasciatus*), Australian Hobbies (*Falco longipennis*), Whistling Kites (*Haliastur sphenurus*) and ravens (*Corvus mellori* and *C. tasmanicus*) for large pines (*Pinus radiata*).
3. No single flowering native tree or shrub is the golden fleece for biological control of farm pests. Different species or taxa have been touted from time to time (e.g. *Bursaria spinosa* and *Leptospermum* spp for nectar-feeding parasitoids, and gum-exuding *Acacia* spp for sugar gliders), but, given the diversity of biophysical conditions and farm pests across the temperate grazing districts, farmers need to invest in diversity to counter all situations. For instance, phyllodinous Acacias are tremendously valuable at 'Connewarran', but more for the nectar flows from the phyllodinous glands that attract beneficial insects: Acacias provide nectar during the late summer 'drought' between January and March when nectar is most scarce in Mediterranean systems (Ford 1979). The particular food webs involving flowers, beneficial parasitoids and pest insects need to be disentangled. Richard has observed that Tea trees (*Leptospermum* spp.) are a most important factor associated with control of sawflies (*Perga* spp.) and chrysomelid leaf beetles. The 'Connewarran' wetlands provide a breeding ground and habitat for dragonflies, and the Black Wattle (*Acacia mearnsii*) plantings provide a haven for swarms of adult dragonflies, which appear to assist in the control of sheep blowfly on the property. Bush flies also seem to be far less of a nuisance than elsewhere. Given the diversity in potentially beneficial parasitoids (especially tachinid and syrphid flies, and thynnid and scoliid wasps), it is necessary to invest in a wide range of flowering plant diversity.
4. Some floral types, such as daisies (*Asteraceae*), Chocolate Lilies (*Arthropogon* spp.) and bluebells (*Wahlenbergia* spp.), attract large numbers of beneficial insects. Since the first 30 cm above the ground is so important in terms of floral diversity, Richard tries to avoid grazing narrow (20-30 m wide) shelterbelts other than in emergencies. He has found that livestock left for 36 hours or more irreparably prune the lower branches of trees and shrubs in narrow shelterbelts, leading to wind tunnelling. Once lost, the lower canopy does not return due to upper canopy shading. He is less concerned about grazing in the wider (≥ 100 m) ecosystem nodal plantings where wind tunnelling is not an issue.

In terms of the relative efficacy of insectivorous birds and beneficial insects, Richard believes that while birds are handy and are a pleasure to have on the farm, and while the farm bird list has increased to 200 species with the revegetation and wetland initiatives on the property, birds are not abundant enough to do the biological control job alone.

What empirical evidence is there of the dollar benefits of the investment in native revegetation for on-farm biological control at 'Connewarran'? Richard estimates that the investment in native vegetation across the property has led to a 30% increase in agricultural income due to the benefits of shade and shelter and biocontrol of farm pests. Lambing percentages are 11% higher in the sheltered parts than the unsheltered parts of the property. Wool production has doubled on average from 27 kg/ha in the 1960s, with some sown pastures cutting up to 84 kg wool/ha and the average wool cut per ewe being 6.5 kg. Richard has little blowfly strike, unlike others in the district, and the HiFert representative maintains that 'Connewarran' has less pasture scarab damage than anywhere else in the district. Tree defoliation by insects is less evident on 'Connewarran' than elsewhere in the district where seminars have been held on dieback. Finally, contractors frequently remark on the pleasant on-farm working environment, so Richard has no trouble obtaining reliable casual labour. However, he is the first to acknowledge that it is difficult or impossible to separate the benefits of improved animal genetics and finer wool, more productive pastures and better drainage *vis a vis* the benefits of biocontrol and shade and shelter on farm income and productivity.

## Best-bet strategies to 'dieback-proof' farms

On the basis of the information above, ten best-bet strategies for 'dieback-proofing' grazing properties have been formulated below (Reid & Landsberg 1999). These strategies have not been tested or supported in the field to my knowledge. It would be appropriate to implement them on farms and to monitor their success and adapt them to suit particular local conditions. It also needs to be said that these strategies target insect-mediated dieback. Comparable sets of strategies might be developed for other causes of dieback.

1. Insect outbreaks are inevitable given climatic cycles. Accepting the inevitability of defoliating insect outbreaks, it is important to maximise tree cover, manage for natural regeneration, and maintain uneven-aged stands to enhance the resilience of farm tree populations.
2. Dieback results from an imbalance between too few eucalypts and too many defoliating insects in the farm environment. Thus it may help to increase the critical mass of farm eucalypts and to regenerate buffer trees around stands of sparse trees to help satiate insects.
3. The foliar quality of farm eucalypts in pastures is enhanced by increased soil nutrients and fertilisation and is thereby made more attractive to defoliating insects. It should help to avoid fertilising within 20 m of farm trees, to avoid increased nutrient uptake by tree roots.
4. Similarly, sheep camping leads to excessive nutrient buildup beneath trees. This may be avoided by increasing shade tree provision elsewhere in the paddock, moving sheep camps by displacing sheep with temporary fencing, and by grazing rotationally. The effect of planned rotational grazing of sheep is to distribute dung and urine more evenly throughout a cell rather than to one or a limited number of sheep camps.
5. High-input pastures are greater sources of pasture scarabs than semi-improved or natural and native pastures. Accordingly, to minimise defoliation of trees in such remnants, sown pastures should be developed as far away from valuable remnant vegetation as possible.
6. In order to bring potential parasitoids and predators into contact with scarabs in paddocks, a fine-scale lattice of ungrazed native understorey should be developed across the farmscape at no greater than 400 m intervals. Parasitoid wasps are much reduced in abundance at 200 m from native vegetation containing flowering shrubs (Campbell & Brown 1995). The ungrazed network of native vegetation should contain forbs, shrubs and trees that provide nectar for native predators and parasitoids of pasture scarabs and other defoliating insects.
7. In developing the habitat latticework for natural biocontrol agents, it may be important to work outwards from existing remnants of native vegetation to encourage the movement of parasitoids and predators into the new plantings and habitats.
8. Across grazed paddocks, it may help to conserve a scatter of naturally occurring farm trees to maintain landscape connectivity for fauna that can use the overstorey as habitat and 'stepping stones' across the landscape.
9. Since sown fertilised pasture produces most pasture scarabs, minimising the area of sown pasture will minimise the abundance of scarabs. It may also help to vary the grazing pressure in any particular pasture between high and low stocking rates because of the depression in scarab abundance in undergrazed and overgrazed pastures (Roberts 1979). Planned rotational grazing (Curtis & Wright 1993) may be a commercially and environmentally acceptable way of achieving this.
10. Insectivorous birds are important consumers of insects in healthy woodland (Ford 1985). On-farm habitat for birds can be enhanced in various ways (Barrett *et al.* 1994): by maintaining or planting a shrub understorey; by tolerating a moderate level of mistletoe; by providing nest boxes for small leaf gleaners (e.g. pardalotes) in the absence of suitable hollow trees; by retaining large woody litter on the ground; by protecting and enhancing riparian vegetation; and by linking larger, healthier remnants with habitat corridors.

## Conclusions

While a considerable amount of information about insect-mediated dieback is now available, the following points need to be emphasised:

- We don't know how well any of the above strategies will work. Accordingly, an adaptive management approach (i.e. iterative cycles of planning, acting, monitoring, reviewing and revising) is advised in the implementation of the strategies.
- Further research on the relative efficacy of different natural control agents (e.g. birds *vs* insects) would be advantageous in order to better focus best-bet mitigation strategies.
- Dieback mechanisms in many places are still not completely understood. Further research on mechanisms would enable more reliable management strategies to be devised.

Given the inevitability of further climatically-driven episodes of severe dieback, it would appear prudent to implement best-bet mitigation strategies immediately in areas already suffering dieback, and perhaps in areas yet to experience severe dieback, to minimise the continuing loss of valuable farm tree populations.

## References

Bacon, P. 1996. *Relationship between water supply, water quality and the performance of river red gums (Eucalyptus camaldulensis) in the Macquarie Marshes of NSW*. Department of Land and Water Conservation, Dubbo.

Barrett G.W., Ford H.A.& Recher H.F. 1994. Conservation of woodland birds in a fragmented rural landscape. *Pacific Conservation Biology* 1: 245-56.

Campbell, A. J. & Brown, G. R. 1995. The Biological Control of Scarabs causing *Eucalyptus* Dieback. A Final Report prepared for the Rural Industries Research and Development Corporation. NSW Agriculture, Sydney.

Carne, P. B., McInnes, R. S. & Green, J. P. 1981. Seasonal fluctuations of the abundance of two leaf-eating insects. In: K. M. Old, G. A. Kile & C. P. Ohmart (eds) *Eucalypt Dieback in Forests and Woodlands*, pp. 121-6. CSIRO, Australia.

Clarke, M. F., Grey, M. J., Britton, D. R. & Loyn, R. H. 1995. *The Noisy Miner Manorina melanocephala and rural dieback in remnant eucalypt woodlands*. Royal Australasian Ornithologists Union, Report No. 98.

Curtis, D. & Wright, T. 1993. Natural regeneration and grazing management – a case study. *Australian Journal of Soil and Water Conservation* 6: 30-4.

Davidson, R. L. 1982. Correcting past mistakes – loss of habitat for predators and parasites of pasture pests. In: K. E. Lee (ed.) *Proceedings of the 3rd Australasian Conference on Grassland Invertebrate Ecology*, Adelaide, 30 November 4 December 1981, pp. 199-206. South Australian Government Printer, Adelaide.

Davidson, R. L. 1984. The value of habitat. In: J. A. Hofler (ed.) *Focus on Farm Trees. The Decline of Trees in the Rural Landscape*, pp. 39-51. Proceedings of the 2nd National Conference on the Decline of Trees in the Rural Landscape, 14-16 May 1984. Government Printer NSW.

Davidson, R. L., Hilditch, J. A., Wiseman, J. R. & Wolfe, V. J. 1979. Growth, fecundity, and mortality responses of Scarabaeidae (*Coleoptera*) contributing to population increases in improved pastures. In: T. K. Crosby & R. P. Pottinger (eds) *Proceedings of the 2nd Australasian Conference on Grassland Invertebrate Ecology*, pp. 66-70. Government Printer, Wellington.

Duggin, J. A. 1981. The use of ecological provinces and land systems in the study of Eucalyptus dieback on the New England Tablelands. In: K. M. Old, G. A. Kile & C. P. Ohmart (eds) *Eucalypt Dieback in Forests and Woodlands*, pp. 245-60. CSIRO, Australia.

Elliott, H. J., Ohmart, C. P. & Wylie, F. R. 1998. *Insect Pests of Australian Forests*. Inkata, Melbourne.

Farrier, D. 1995. Policy instruments for conserving biodiversity on private land. In: R. A. Bradstock, T. D. Auld, D. A. Keith, R. T. Kingsford, D. Lunney & D. P. Sivertsen (eds) *Conserving Biodiversity: Threats and Solutions*, pp. 337-59. Surrey Beatty & Sons, Chipping Norton.

Ford, H. A. 1979. Interspecific competition in Australian honeyeaters - depletion of common resources. *Australian Journal of Ecology* 4: 145-64.

Ford, H. A. 1981. Birds and eucalypt dieback. In: K. M. Old, G. A. Kile & C. P. Ohmart (eds) *Eucalypt Dieback in Forests and Woodlands*, pp. 112-20. CSIRO, Melbourne.

Ford, H. A. 1985. The bird community in eucalypt woodland and eucalypt dieback in the Northern Tablelands of New South Wales. In: A. Keast, H. F. Recher, H. Ford & D. Saunders (eds) *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management*, pp. 333-40. Surrey Beatty, Chipping Norton.

George, R. J., McFarlane, D. J. & Speed, R. J. 1996. The consequences of a changing hydrologic environment for native vegetation in southwestern Australia. In: D. A. Saunders, J. L. Craig & E. M. Mattiske (eds) *Nature Conservation 4: the Role of Networks*, pp. 9-22. Surrey Beatty and Sons, Chipping Norton.

Hutchinson, K. J. 1997. Grazing systems. In: J. L. Wheeler (ed.) *CSIRO Armidale - Fifty Years of Pastoral Research*, pp. 33-66. University of New England, Armidale.

Hutchinson, K. J. & King, K. L. 1980. The effects of sheep stocking levels on invertebrae abundance, biomass and energy utlization in a temperate, sown grassland. *Journal of Applied Ecology* 17: 369-87.

Jones, A. D., Davies, H. I. & Sinden, J. A. 1990. Relationships between eucalypt dieback, land, and land use in southern New England, New South Wales. *Australian Forestry* 53: 13-23.

Landsberg, J. 1988. Dieback of rural eucalypts: tree phenology and damage caused by leaf-feeding insects. *Australian Journal of Ecology* 13: 251-67.

Landsberg, J. 1990a. Dieback of rural eucalypts: does insect herbivory relate to dietary quality of tree foliage? *Australian Journal of Ecology* 15: 73-87.

Landsberg, J. 1990b. Dieback of rural eucalypts: response of foliar dietary quality and herbivory to defoliation. *Australian Journal of Ecology* 15: 89-96.

Landsberg, J. & Wylie, F. R. 1988. Dieback of rural trees in Australia. *GeoJournal* 17: 231-37.

Landsberg, J. & Wylie, R. 1991. A review of rural dieback in Australia. *Growback '91*: 3-11.

Lowman, M. D. & Heatwole, H. 1992. Spatial and temporal variability in defoliation of Australian eucalypts. *Ecology* 73: 129-42

Loyn, R. H. & Middleton, W. G. D. 1981. Eucalypt decline and wildlife in rural areas. In: K. M. Old, G. A. Kile & C. P. Ohmart (eds) *Eucalypt Dieback in Forests and Woodlands*, pp. 95-111. CSIRO, Mebourne.

Mackay, S. 1978. Dying eucalypts of the New England tablelands. *Forest and Timber* 14: 18-20.

Mackay, S. M., Humphreys, F. R., Clark, R. V., Nicholson, D. W. & Lind, P. R. 1984. *Native Tree Dieback and Mortality on the New England Tablelands of New South Wales*. Research Paper No. 3, Forestry Commission of NSW, Sydney.

Norton, A. 1886. On the decadence of Australian forests. *Proceedings of the Royal Society of Queensland* 3: 15-22.

Ohmart, C. P. & Edwards, P. B. 1991. Insect herbivory on eucalypts. *Annual Review of Entomology* 36: 637-57.

Podger, F. D., James, S. H. & Mulcahy, M. J. 1996. Dieback in Western Australia. Volume 1 – Report and Recommendations. Report by the Western Australian Dieback Review Panel to the Honourable Minister for the Environment. Perth.

Prescott, A. M. 1996. Successful extension programmes for nature conservation in South Australia's rural areas. In: D. A. Saunders, J. L. Craig & E. M. Mattiske (eds) *Nature Conservation 4: the Role of Networks*, pp. 601-8. Surrey Beatty and Sons, Chipping Norton.

Reid, N. & Landsberg, J. 1999. Tree decline in agricultural landscapes: what we stand to lose. In: R. Hobbs & C. Yates (eds) *Ecology, Management and Conservation of Temperate Woodlands in Australia* (in press). Surrey Beatty and Sons, Chipping Norton.

Roberts, R. J. 1979. The theory and use of alternating stocking rates to control pasture pests. In: T. K. Crosby & R. P. Pottinger. *Proceedings of the 2nd Australasian Conference on Grassland Invertebrate Ecology*, pp. 179-80. Government Printer, Wellington, New Zealand.

Roberts, R. J., Campbell, A. J., Porter, M. R. & Sawtell, N. L. 1982. The distribution and abundance of pasture scarabs in relation to *Eucalyptus* trees. In: K. E. Lee (ed.) *Proceedings of the 3rd Australasian Conference on Grassland Invertebrate Ecology*, Adelaide, 30 November – 4 December 1981, pp. 207-14. South Australian Government Printer, Adelaide.

Sinden, J. A., Jones, A. D. & Fleming, P. J. 1983. *Relationships between eucalypt dieback and farm income, stocking rate and land value in southern New England, New South Wales*. University of New England, Armidale.

Smith, A. P. 1995. *Sugar gliders, wattles and rural eucalypt dieback*. Department of Ecosystem Management, Armidale.

Weatherly, R. 1997. Benefits of an improved fertility system for the ecosystem. In: *Proceedings of the Victorian Grasslands Society Conference*, pp. 61-6.

Whalley, R. D. B. & Curtis, D. J. 1991. Natural regeneration of eucalypts on grazing land on the Northern Tablelands of NSW, Australia. In: *Proceedings of the 4th International Rangelands Congress*, Montpellier, France, April 1991.

White, T. C. R. 1986. Weather, *Eucalyptus* dieback in New England, and a general hypothesis of the cause of dieback. *Pacific Science* 40: 58-78.

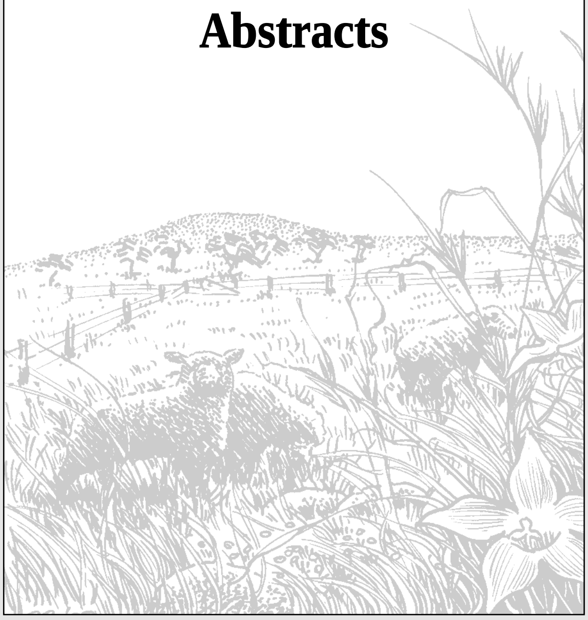
Williams, J. B. & Nadolny, C. 1981. A survey of eucalypt species involved in New England dieback. In: K. M. Old, G. A. Kile & C. P. Ohmart (eds) *Eucalypt Dieback in Forests and Woodlands*, pp. 74-86. CSIRO, Melbourne.

Wilson, S. M., Whitham, J. A. H., Bhati, U. N., Horvath, D. & Tran, Y. D. 1995. *Trees on Farms. Survey of Trees on Australian Farms: 1993-94*. ABARE Research Report 95.7, Canberra.

Wylie, F. R., Johnston, P. J. M. & Eisemann, R. L. 1993. *A survey of native tree dieback in Queensland*. Forest Research Institute Research Paper No. 16. Queensland Department of Primary industries, Forest Service.

Wylie, F. R. & Bevege, D. I. 1981. Eucalypt diebacks in Queensland. In: K. M. Old, G. A. Kile & C. P. Ohmart (eds) *Eucalypt Dieback in Forests and Woodlands*, pp. 31-6. CSIRO, Australia.

# Poster Abstracts



# Tasmanian grassland conservation and management

Phil Barker[1], Louise Gilfedder, Sean Cadman & Renee Nicholson

[1]Resource Management and Conservation
Department of Primary Industry, Water and Environment (DPIWE)
GPO Box 44A, Hobart TAS 7001
pbarker@dpiwe.tas.gov.au

Lowland native grassland is the most depleted and degraded and, consequently, most endangered vegetation formation in Tasmania. Current use of native grasslands has a very long history and is, in almost all cases, compatible with nature conservation. Changes in ownership and economic circumstances will inevitably lead to changes in landuse practices. The present trend toward increased cropping may see a second wave of grassland loss if sites are not secured by management agreements. The path toward lowland grassland conservation on private land in Tasmania must be perceived as beneficial by graziers. It must also result in a cessation of the clearance of the grassland remnants. The form of any management agreement must therefore be developed with the support and assistance of private grassland owners. This poster outlines the current status of the Grasslands Recovery Process in Tasmania and presents ideas on the role of conservation planning to identify roles for grassland remnants in the context of financially viable management of the whole farm.

---

# Grassy ecosystems of the Victorian Plains

Tim J. Barlow[1] & Vanessa L. Craigie[2]

[1] Bushcare Grassy Ecosystems Project Officer
c/- Victorian National Parks Association
10 Parliament Place
East Melbourne VIC 3002
t.barlow@latrobe.edu.au

[2] Grassland Coordinator Flora & Fauna Program
Department of Natural Resources and Environment
4th floor, 250 Victoria Parade,
East Melbourne VIC 3002
vanessa.craigie@nre.vic.gov.au

At the time of European settlement, approximately 6,970,000 ha of tussock grassland, grassy swamps and grassy woodlands occurred in Victoria. Collectively described as the Victorian Plains, these areas supported the establishment of agriculture in Victoria to the extent that less than 1% of the original area retains native vegetation cover.

The major areas are mapped, together with data on the conservation status of grassy ecosystems in these bioregions. Examples of important vegetation types in these bioregions are presented, as is information on the threats and current conservation strategies.

Two examples of current and potential economic values of indigenous grassland flora, other than for stock grazing, are briefly discussed. It is suggested the entire community, including agriculturalists and urban people, must act to support the remnants of this ecosystem to both preserve the past and provide for the future.

---

# Innovation in native grasses (harvesting & sowing techniques)

Andrew A. Briggs

Native Grasses Officer
Central West Department of Land and Water Conservation
P.O. Box 207, Wellington NSW 2820

The greatest problem facing the usage of native grasses in an agricultural landscape is the availability of seed and information on how to establish warm season perennial native grasses. Such information is essential for recharge control in the Central West of NSW and elsewhere throughout Australia.

To overcome this shortfall, the Department of Land and Water Conservation has instigated the Native Grasses Innovation and Development Program. This program has, in conjunction with Barney's Reef Landcare Group and Rosevale Engineering, made major breakthroughs into the development of specialised harvesting and seeding equipment. Such technological advancements now make possible the large scale harvesting and sowing of a wide range of native grasses; previously impossible with existing broadacre technology.

These breakthroughs will have enormous benefits to dryland agriculture and conservation farming, revegetation and, in particular, dryland salinity control through the reduction of groundwater recharge.

---

# Grassland fauna – the Pygmy Bluetongue lizard

Sylvia G. Clarke

Pygmy Bluetongue Recovery Program, Natural Sciences, SA Museum
North Terrace, Adelaide SA 5000
sylviac@senet.com.au

Twelve populations of the peculiar Pygmy Bluetongue lizard (*Tiliqua adelaidensis*) survive in grazed native grassland in the Mid-North of South Australia, a remnant of their former distribution, which extended as far south as the Adelaide plains. The present populations are geographically isolated, each being surrounded by cultivated land, and within each site the lizards exhibit a clumped distribution ranging from 15 to 200 animals per hectare. Pygmy Bluetongues lead a largely sedentary life in burrows dug by wolf spiders and trapdoor spiders. Active by day, they feed on insects, supplemented by plant material. Their maximum length is about 18 cm and, from three years of age, females can have up to 4 live young every year. Their main predators are raptors and elapid snakes.

Pygmy Bluetongues only survive in native grassland that has never been cultivated, but the relationship is not simple and the largest populations are not in the most pristine grasslands. Other factors, still uncertain, must also be important in determining their abundance and distribution. All known populations are on private land and the monitored populations appear stable. The survival of the species will largely depend on landholders' willingness to ensure that potentially disruptive landuse practices (e.g. salt bush planting, spraying grasshoppers) do not impact on areas where Pygmy Bluetongues occur. Over the next year it is hoped that management agreements can be negotiated with some landholders, as recognition of the importance of their role in the survival of these distinctive lizards.

---

# Grassy ecosystems of the NSW Southern Tablelands

David Eddy[1], Sarah Sharp[2] & Rainer Rehwinkel[3]

[1] World Wide Fund for Nature Australia,
11 Gurubun Cl, Ngunnawal ACT 2913
deddy@ozemail.com.au
[2] Environment ACT, Wildlife Research and Monitoring, Canberra ACT
[3] NSW National Parks & Wildlife Service, Southern Zone Team, Queanbeyan NSW

The Southern Tablelands of NSW and the ACT occupy an area of about 3.5 million hectares between the Abercrombie River in the north and the Victorian border in the south. Most of the area lies between 550 and 1200 m in elevation. Treeless grasslands and grassy woodlands form the major ecosystems of the tablelands. Nearly two centuries of European settlement and development have strongly modified these ecosystems in structure, composition, native species richness and weed status. The ecosystems are generally fragmented and increasingly subject to the threat of extinction, as are several component plant and animal species. Relatively undisturbed grasslands and woodlands are now rare.

The major native grassland dominants include *Themeda*, *Poa*, *Austrostipa* and *Austrodanthonia*. Some areas are dominated by *Aristida* or *Bothriochloa*, and a significant area of native pasture is dominated by *Microlaena*. Several hundred additional native herb species have been recorded in these ecosystems. Grassy woodlands dominated by *Eucalyptus melliodora*, *E. blakelyi*, *E. bridgesiana*, *E. pauciflora* and *E. stellulata* have essentially similar flora in their herb layers. The understorey of grassy woodlands and forests on soils derived from sedimentary parent material is often dominated by *Joycea pallida*, though it rarely occurs as a grassland dominant.

Government, non-government and community organisations are working together to identify, protect and conserve the higher quality remnants within the region, and to educate agency staff and the community of the value and requirements of these ecosystems. While over the past five years there have been several grassland sites added to the reserve system in both NSW and the ACT, the major emphasis is the protection of off-reserve sites, for which management agreements are being developed and implemented. Where possible, management practices being used to maintain current landuses (such as sustainable pasture production or recreation) are retained, where they are compatible with the conservation of the threatened ecological communities and species. A major objective for conservation of grassy ecosystems is to manage for the maintenance of habitat diversity.

# Agriculture and conservation: is there a conflict?

Denys L. Garden

NSW Agriculture
GPO Box 1600, Canberra ACT 2601
d.garden@pi.csiro.au

Most agricultural practices accelerate change in grassland. Changes have been so complete that it is debatable if any grassland areas remain in their pristine state. If this is the case, then one may ask whether any areas should be conserved, since they do not fully represent the original vegetation. Also, the fact that agriculture appears to alter composition so dramatically suggests that there is risk in placing conservation areas on private land where agricultural practices are continuing. Important questions are how much change has occurred, and who should be responsible for conservation in agricultural areas?

Agricultural management practices include grazing, fertiliser and disturbance by cultivation and herbicides. Unfortunately, economic pressures to remain viable force farmers to utilise their land more intensively by adopting these practices. While farmers may have ideals of preserving vegetation, unless they have sufficient land area (or alternative sources of income) to obtain a reasonable standard of living, this may not be possible. Therefore, one might conclude that agriculture and conservation are incompatible, at least on the same land area.

However, there are two aspects that are worthy of consideration. Firstly, there are areas that have undergone less change and hence are closer to the original composition. Many of these areas contain rare or threatened plants or animals and, if no action is taken, these may disappear. Secondly, although agriculture and conservation may be incompatible on the same land area, this does not mean that they cannot be carried out jointly on different areas in the rural landscape.

The setting aside of areas on private land has problems because of economic pressures and the lack of understanding of the special needs of these areas. Therefore, reservation with management by trained ecologists seems to be the only viable alternative. This must involve the wider community through government funding. If the community demands conservation, the community must be prepared to accept the cost, and not insist that farmers be financially responsible for conservation on their behalf.

# Conservation of native grasslands in the Darling Downs region, south-east Queensland

Alison Goodland

Darling Downs Remnant Grasslands Project
World Wide Fund for Nature
PO Box 1306, Toowoomba Qld 4350
agoodland@telstra.easymail.com.au

This project was developed through the Queensland Herbarium and World Wide Fund for Nature to conserve native grasslands in the Darling Downs region, south-east Queensland. It is sponsored by the Bushcare Program of the Commonwealth Government's Natural Heritage Trust.

Due to extensive fragmentation of the Darling Downs area, grasslands and rare and threatened grassland flora species are now mainly restricted to road reserves, stock routes and rail easements. Thus this project aims to facilitate the coordination of all stakeholders of these 3 entities and develop management guidelines and strategies to ensure their protection.

The project comprises:

- mapping of significant sites (GIS development);
- liaison with stakeholder groups;
- development of site management plans and overall strategies;
- community awareness; and
- monitoring

# Mapping the pre-European extent of the natural grasslands of the Liverpool Plains, NSW

Des Lang

Gunnedah Research Centre
Department of Land and Water Conservation (DLWC), Gunnedah NSW 2380
dlang@dlwc.nsw.gov.au

The Liverpool Plains has been identified as one of the five significant areas of natural grasslands in New South Wales. However, the grasslands have been radically altered by the clearing of adjacent woodlands, overgrazing, changed fire regimes and cultivation for crops and improved pastures. A knowledge of the extent and nature of these grasslands is required before any responsible attempt can be made to conserve and manage presumed remnant areas. Historical records were examined for evidence that would identify the tree line and the nature of the original vegetation.

A complex of about twelve treeless 'plains' was identified from the journal of two explorers, an 1880 paper to the Royal Society of NSW, and NSW Lands Department survey plans dating from 1839. Tree lines were shown with a high level of accuracy on the survey plans, and with less accuracy in the 1880 paper. The survey plans also indicated dominant species, the nature of the vegetation and soil type.

Historical documents can provide valuable insight into the nature and condition of the original landscape and clues on the impact of human activities, which may be useful for the development of meaningful and sensible land management strategies. However, many of these historical documents are relatively inaccessible and some are in danger of being lost.

---

# Conservation trends on the Northern Tablelands of NSW

Chris Nadolny

Department of Land and Water Conservation
PO Box U245, Armidale NSW 2351
cnadolny@dlwc.nsw.gov.au

About 70% of the Northern Tablelands consists of native/naturalised pastures or forests and woodlands with predominantly native groundcover. The area of native grassland appears to be increasing as summer-active native grasses take over degraded sown pastures. Original grasslands in good condition are rare and prominent examples have recently been destroyed. Some weeds, particularly exotic perennial grasses, are spreading. Eucalypt dieback was severe in the 1970s. It is now more localised and regeneration is prolific in some areas. The Landcare movement is strong, with landholders taking a proactive approach to natural resource planning and management.

---

# Grassland restoration on the Western Basalt Plains

Cheryl O'Dwyer

Zoological Parks and Gardens Board
PO Box 74, Parkville VIC 3052
Codwyer@zoo.org.au

Victoria's Open Range Zoo (VORZ) is located on the western basalt plains near Werribee. The basalt plains grasslands have diminished since European settlement and are one of the most endangered ecosystems in Victoria. Grasslands are poorly represented in conservation reserves and their education potential has been little realised. A new exhibit at VORZ, 'Volcanic Plains', has been established to provide habitat for endangered plants and animals within the basalt grasslands. This display also provides both a pleasant landscaped encounter and an educational experience. Within the volcanic plains exhibit, a one acre plot has been set aside for the re-establishment of native grasses for the reintroduction of the Golden Sun Moth (*Synemon plana*). The site will be sprayed a number of times throughout the year and scraped to produce bare earth. With the assistance of Friends of the Zoos (FOTZ) and volunteers, 40,000 *Austrodanthonia* spp. plants will be planted as habitat for the Golden Sun Moth. Inter-tussock herbs and forbs will be added throughout the establishment phase, providing a complete grassland experience. There are plans to include other native endangered plants and animals, such as the Button Wrinklewort (Rutidosis leptorhynchoides), Double-tailed Orchid (*Diuris fragrantissime*), Eastern Barred Bandicoot (*Peremeles gunnii*) and Striped Legless Lizard (*Delmar impar*).

# Bush for Wildlife

Bernadette O'Leary & Carolyn Paris

Sustainable Landscapes Branch, Environment Australia
PO Box 787, Canberra ACT 2601
bernadette.oleary@ea.gov.au or carolyn.paris@ea.gov.au

In 1998, the Commonwealth Government made a commitment to place greater emphasis on wildlife and habitat protection through the Bush for Wildlife initiative. The national approach of Bush for Wildlife further strengthens Australia's off-reserve conservation of biodiversity in both rural and urban areas. The initiative will bring together a number of existing Commonwealth Government Natural Heritage Trust programs, such as Bushcare, the Endangered Species Program and the National Reserves System Program.

Bush for Wildlife has three mechanisms for bringing about change:

*National Coordination*—to improve access to information about wildlife habitat management and protection by existing urban and rural conservation groups and programs throughout Australia. This will provide the opportunity for highlighting and sharing best-practice, and coordinating communication activities. One important example of national coordination is working with state based *Land for Wildlife* schemes.

*Bush for Wildlife Revolving Fund(s)*—to be established nationally, modelled on the Victorian Trust for Nature fund. These will be managed by organisations who will: identify and purchase land containing significant native vegetation; place a covenant on the title to the land to protect it in perpetuity; and then resell the land to sympathetic owners. Funds from property sales will be returned to the Revolving Fund(s) for further property purchases. The areas of native vegetation protected through Revolving Funds will complement and extend existing State reserves systems, including those established with the assistance of the National Reserves System Program. Revolving funds can provide an avenue for protecting significant native vegetation that fails to meet the strict criteria of more formal reservation processes.

*Refocussing existing Natural Heritage Trust grant guidelines*—to place a greater emphasis on wildlife and habitat protection and management within existing Natural Heritage Trust programs, including through the One-Stop-Shop grant funding process.

# Regional Biodiversity Planning Program

Alison Oppermann

Department of the Environment, Heritage and Aboriginal Affairs
GPO Box 1047, Adelaide SA 5001
aopperman@dehaa.sa.gov.au

In recognition of the importance of conserving biodiversity, the Government of South Australia is developing a series of regional biodiversity plans to guide priority on-ground actions for the conservation, management and rehabilitation of species and habitats. This program is being greatly assisted by the Commonwealth Government through the Natural Heritage Trust. Plans provide a focus for the conservation and management of biodiversity within a region so that a strategic approach to implementing conservation actions can be achieved. This focus also provides a framework for integrating biodiversity conservation with other regional natural resource management issues and plans.

Preparation of regional biodiversity plans includes three phases: data inventory, data analysis and community consultation. Data inventory comprises a 'desk-top' survey of existing biological data for each region from a wide variety of sources. The flora and fauna information is consolidated and distribution of vegetation communities and threatened species mapped. Gaps in existing biological information for the region are also identified. Data analysis includes identification and mapping of priority areas and plant communities/habitats and species most at risk. Conservation issues and priorities and management strategies are then determined in consultation with the community.

A Biodiversity Plan for the South East was prepared as a pilot project and will be published in the next few months. Data inventories have been completed for the Eyre Peninsula, Northern Agricultural District, Murray Darling Basin SA, Mt Lofty Ranges and Kangaroo Island and will serve as the base for the preparation of the Biodiversity Plans over the next 12 months.

---

# Does this map show that your pastures have native grasses in them? Is it accurate?

Ann Prescott[1], Greg Wilkins[2] & Lee Heard[2]

[1] World Wide Fund for Nature, SA Temperate Grasslands Project,
120 Wakefield St, Adelaide, 5000
annpres@ozemail.com.au
[2] Planning SA, GPO Box 1815, Adelaide SA 5001

Native grassy woodlands and grasslands have been difficult to map through traditional methods. Mapping is useful to assist land mangers and community groups to make good production and conservation decisions, and to highlight important areas for biodiversity. To overcome difficulties in distinguishing native grasslands and grassy woodlands from other vegetation types, a series of layers of information have been used. These include historic records indicating where native grasslands occurred, native grassland areas identified by specialised studies, and estimations of non-cultivated land based on slope. Local Soil Board plans indicate that 10 % slope is the upper limit for sustainable cultivation. Further work will consider using available soil landscape unit information to help identify additional areas. Local landholders are encouraged to provide further information or feedback about this map.

---

# Growth of young eucalypt seedlings in a partly-cleared woodland on the Central Tablelands of NSW

W.S. Semple[1] and T.B. Koen[2]

Department of Land and Water Conservation
[1] PO Box 53, Orange NSW 2800
[2] PO Box 445, Cowra NSW 2794

Aim: To monitor the progress of eucalypt recruitment in a moderately high altitude (c.850 m a.s.l.) partly-cleared box (*Eucalyptus melliodora* - *E. blakelyi* - *E. bridgesiana*) woodland with a grassy (*Themeda australis*) understorey near Orange on the Central Tablelands of NSW.

The site: The paddock was burnt in spring 1994 and grazing by domestic stock was discontinued in January 1995. Seedlings first became evident amongst the high bulk (c.6 t/ha) of native pasture in early 1996. Most were of Apple Box (*E. bridgesiana*) and all had a small lignotuber when first observed.

Methods: Monitoring of seedling heights commenced in October 1996 and continued (as increasing numbers of seedlings became evident during late 1996 and early 1997) until May 1999.

Results: A comparison of Orange rainfall records with those associated with successful eucalypt recruitment in similar environments elsewhere (see Lawrence *et al*. 1998) suggested that the seedlings probably emerged in late 1994. The rate of growth (as measured by the length of the stem from the ground surface to the tip of the uppermost green leaf) was very slow: an average of 16.6 cm/year from when measurements commenced in October 1996. The pattern of growth was marked by periods of no growth during the cooler months. This appeared to be independent of rainfall as the cool season (April-September) in 1997 was dry (302 mm) whereas it was wet (880 mm) in 1998.

Conclusions: Eucalypt seedlings grew very slowly under natural conditions at moderately high altitude and no growth occurred during the cooler months. Most seedlings were not above sheep grazing height 4 years after emergence. Even during the growing period, growth was subdued—probably due to competition from the warm-season native grasses. Although higher growth rates would have been expected where competition was controlled, other work (e.g. Semple and Koen 1997) suggests that if an uncontrolled non-native pasture had been present, growth and survival of seedlings would have been negligible.

Acknowledgments: Particular thanks to David and Katherine Pfanner and family for their generous hospitality and assistance during the period of observations on ‘Pinaroo’.

## References

Lawrence, J., Semple, W.S. & Koen, T.B. 1998. Experimental attempts at encouraging eucalypt regeneration in exotic pastures of northern Victoria and central western NSW. *Proc. Linn. Soc*. NSW. 119: 137-54.

Semple, W.S. & Koen, T.B. 1997. Effect of seedbed on emergence and establishment from surface sown and direct drilled seed of *Eucalyptus* spp. and *Dodonaea viscosa*. *Range l. J.* 19: 80-94.

# The grasslands of the Lofty Block Bioregion

Meg Robertson and Peter Lang (Presented by Adrian Stokes[1])

[1] Threatened Species and Communities, Biodiversity Branch
Department of the Environment, Heritage & Aboriginal Affairs
alstokes@dehaa.sa.gov.au

Floristic analysis of vegetation survey data identified twelve distinct floristic groups of temperate native grassland and grassy woodland. Of particular interest are the *Lomandra effusa* grassland and *Lomandra multiflora ssp. dura* tussock grassland which may be endemic to South Australia.

The values, threats and current management of native grasslands and grassy woodlands include:

- They provide habitat for threatened flora (e.g. Small Scurf Pea *Cullen parvum*) and fauna (e.g. Pygmy Bluetongue *Tiliqua adelaidensis*).
- There is little high quality grassland and woodland in the National Parks and Wildlife Reserve System or under Heritage Agreement in South Australia.
- Most remaining grassland is on private land, generally with various grazing regimes and a wide range of condition. Few are high quality but there are many with potential for improvement through changes to management.
- Small areas of grassland and grassy woodland survive by default on minor public land including cemeteries and town parklands and are also at risk from ad hoc management.
- Main weed threats are:
  - Herbaceous species—annual grasses, wild sage, salvation jane, clovers and medics in grassland; these and bridal creeper in grassy woodland.
  - Woody species—horehound and boxthorn in grassland; olives, boneseed and topped lavender in grassy woodland.
- Other threats: inappropriate tree planting, clearance (by overgrazing, ploughing, fertilising and/or seeding), lack of awareness and inadvertent detrimental management.

# Managing native vegetation – Learning From Farmers

Gavin Wall

Uranquinty NSW 2652
gavinwall@ozemail.com.au

This project provides an opportunity for farmers, and others, to learn from farmers who have successfully utilised native vegetation as an integral component of their overall management. The project is funded by the Commonwealth Government's Natural Heritage Trust and managed by Greening Australia & the Murray (NSW) Catchment Management Committee.

Aims:

- To encourage landholders to adopt sustainable native vegetation management practices by establishing a series of learning sites throughout the NSW Murray River Catchment.

Objectives:

- to ensure that farmers who have demonstrated sound management of native vegetation are recognised as experts in this field;
- to establish a network of farmers and learning sites across the NSW Murray Catchment;
- to facilitate educational experiences about native vegetation for other farmers;
- for the farmer network to grow over time and become a self-managing / funding operation.

Activities:

- establish a register of properties that have value as learning sites for other landholders and the wider community in native vegetation management;
- develop these sites as learning sites through production of interpretive material making information about these sites publicly available;
- promote these sites to other landholders and the wider community through a series of media stories, field days / workshops and other promotional activities;
- encourage owners of these sites to act as mentors or coaches to other landholders;
- provide incentives to the owners of the learning sites to encourage and recognise their involvement in these activities including the reimbursement of expenses and an appropriate hourly payment that recognises the value of their work and expertise.

Outcomes:

- acknowledge the work, dedication and expertise of landholders (of the 12 sites) for their conservation and management of the native vegetation on their properties;
- draw upon the landholder network as a process of peer education;
- increase the number of landholders adopting sustainable management practices for remnant vegetation;
- increase the skills and knowledge amongst landholders concerning the management of remnant vegetation;
- development of best practices for remnant vegetation within agricultural systems;
- develop a brand logo which reflects quality assured production standards, in conjunction with environmentally sustainable land management procedures incorporating native vegetation.

Statement of purpose:

We want to share our attitudes about native vegetation and fauna management and influence whole communities through awareness raising and education. We want to been seen as productive rural businesses that understand the benefits of native vegetation and fauna in balance with rural production. We want to influence the wider community to adopt best management practices of land management for sustainability, achieving production and maintenance of biodiversity together.

# Effects of established trees on native temperate pasture growth

Williams, David G.1, Paul Wallace[1], Mutjinde Katjiua[2], Nick Abel[3], Greg McKeon[4]

[1] Applied Ecology Research Group, University of Canberra
[2] Faculty of Agriculture and Natural Resources, University of Namibia
[3] CSIRO Wildlife & Ecology, Canberra
[4] Queensland Department of Natural Resources, Brisbane

The planting or retention of trees in temperate pasture systems has been advocated to address the broad environmental effects of forest clearance and pasture improvement. These effects are now seen to threaten the sustainability of pasture systems through modification to water and nutrient cycles. Native tree cover is still present in many pasture lands of Australia, especially on steeper slopes and poorer soils. The pasture in these situations is commonly rich in native grass and forb species, whose agronomic potential and response to tree cover has been poorly studied.

This study aimed to determine the effects of established tree cover on native pasture production under grazing on the Southern Tablelands of New South Wales. We made comparisons between treed (basal area 10-20 $m^2$ ha-1) and open fixed plots, and also between survey plots which covered the range (0-30 $m^2$ ha-1) of tree basal area within a paddock. Pasture biomass, production and offtake were measured seasonally, as well as pasture digestibility, protein content, soil nutrient status and microclimate.

Overall we found that the treed pasture had higher seasonal production, mainly seen in relatively greater winter growth, and consumption was also higher under the trees. The results suggest that trees in these pastures provide additional environmental heterogeneity that operates on the available species to influence their biomass contributions. Given the desirability of having deep-rooted perennial components in pasture lands, this study suggests that, in some places at least, tree cover can provide wider environmental services without compromising current levels of pasture production.