The Australian Rangeland Society

RANGE MANAGEMENT NEWSLETTER
An official publication of The Australian Rangeland Society
ISSN 0812-4930

ISSN 0812-4930

The Australian Rangeland Society

Range management Newsletter

No. 02/1 March 2002

Registered by: Australia Post – Print Post No. 545270/00001

No. 02/1 March 2002

EDITOR (*RMN*)
Noelene Duckett
7 Belcarra Place
The Woodlands Texas 77382 USA
Ph: 0011 1 281 681 1551
Email: nduckett@ozemail.com.au

EDITOR (Rangeland Journal)
Assoc. Prof. Wal Whalley
School of Rural Science & Natural Resources
University of New England
Armidale NSW 2351
Ph: 02 6773 2477 Fax: 02 6773 3283
Email: rwhalley@metz.une.edu.au

PRESIDENT
Merri Tothill
Primary Industries and Resources
Port Augusta SA 5700
Ph: 08 8648 5170 Fax: 08 8648 5161
Email: Tothill.Meredith@saugov.sa.gov.au

VICE PRESIDENT
David Lord
Thackaringa Station
Broken Hill NSW 2880
Ph: 08 8091 1638 Fax: 08 8091 1540
Email: thackaringa@bigpond.com

FINANCE & AUDIT OFFICER
John Maconochie
Department of Environment & Heritage
GPO Box 1047, Adelaide SA 5001
Ph: 08 8204 8870 Fax: 08 8204 8859
Email: maconochie.john@saugov.sa.gov.au

SECRETARY
Sarah Nicolson
Intercomm Event Coordination
22 Edmund Ave, Unley SA 5061
Ph: 08 8357 3378 Fax: 08 8357 3389
Email: nicolson@w130.aone.net.au

MEMBER SERVICES OFFICER
Robyn Cowley
Department of Primary Industries and Fisheries
PO Box 1346, Katherine NT 0851
Ph: 08 8973 9749 Fax: 08 8973 9777
Email: robyn.cowley@dpif.nt.gov.au

COMMUNICATION OFFICER
Lachlan Pegler
Department of Natural Resources and Mining
PO Box 224, Charleville QLD 4470
Ph: 07 4654 4207 Fax: 07 4654 4225
Email: lachlan.pegler@dnr.qld.gov.au

MEMBERSHIP OFFICER
Ian Watson
Department of Agriculture
PO Box 483, Northam WA 6401
Ph: 08 9690 2128 Fax: 08 9622 1902
Email: iwatson@agric.wa.gov.au

SUBSCRIPTION MANAGER
Rob Richards
Department of Land and Water Conservation
PO Box 77, Condobolin NSW 2877
Ph: 02 6895 2033 Fax: 02 6895 3406
Email: rrichards@dlwc.nsw.gov.au

CONTENTS **Range Management Newsletter 02/1**

FROM THE EDITOR

Noelene Duckett, 7 Belcarra Place, The Woodlands, Texas, USA, 77382. Email: nduckett@ozemail.com.au

Welcome to the first issue of the Range Management Newsletter for 2002.

This issue includes three technical papers. Gary Bastin and others have written two companion articles which extend their work in the late 1990's on landscape function. The first article reports on how vegetation patch attributes derived from aerial videography change along an environmental gradient from northern South Australia to the Victoria River District in the Northern Territory. In the second article, the authors have described a 'directional leakiness index' which is based on the cover and arrangement of patches. They show how this index may be useful in monitoring change in landscape function under grazing.

David Lord's article examines the effect of rabbit grazing on sucker recruitment of *Acacia carnei* following the arrival of Rabbit Calicivirus Disease (RCD). David has demonstrated using trial plots on his own land that even at low numbers rabbits are able to prevent successful sucker recruitment of this species. David's conclusions are supportive of those described by Andy Sharp *et al* in the most recent *Rangeland Journal* (see abstract of this article on p 20): they similarly believe that other management actions, in addition to RCD, are required to reduce rabbits in the semi-arid zones.

Lachlan Pegler, the ARS Communication Officer, has put together a number of articles relating to Council business. These include details of previous Council decisions and notice of the upcoming AGM. Please note that notices of motions to be put before the meeting must be received by the Secretary on or before 14 May for discussion at the 21 May meeting. Council are also currently considering updating the ARS logo. Be creative and send in your ideas – you may win a years membership to the Society!

Two important rangeland conferences are coming up in the next 18 months. Firstly, there is the ARS Biennial Conference to be held in Kalgoorlie in early September this year. Following this, the VII International Rangelands Congress will take place in Durban, South Africa in late July 2003. Details about both of these conferences are available in this issue with further information available online at the conference websites. Please note that the IRC website indicates that abstracts for papers are due by 15 May 2002.

Finally, the newsletter contains the usual Information Snippets section which includes details of publications, conferences, websites and awards which may be of interest to our readers. This section also includes the abstracts of articles from the latest *Rangeland Journal.*

As always I will be looking forward to receiving your contributions for the July issue of the newsletter. Please have articles and news items to me by late May if possible to allow time for printing and posting.

•

VEGETATION PATCHES: HOW DO THEY CHANGE ALONG AN ENVIRONMENTAL GRADIENT?

Gary Bastin, Janine Kinloch, Vanessa Chewings and Graham Pearce, CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs NT 0871
John Ludwig, Tropical Savannas CRC and CSIRO Sustainable Ecosystems, PO Box 780, Atherton Qld 4883
Robert Eager and Adam Liedloff, Tropical Savannas CRC and CSIRO Sustainable Ecosystems, PMB 44, Winnellie NT 0822

Introduction

Patches of perennial vegetation serve an important function in the rangelands by capturing and retaining critical resources such as rainwater, organic matter and soil sediments and nutrients (Tongway and Ludwig 1997a). Degree of runoff and soil loss is obviously related to vegetation cover and landscapes with many vegetation patches covering their surfaces more efficiently retain and utilize resources (Tongway and Ludwig 1997b). These landscapes are termed conserving or highly functional systems, whereas landscapes with few such patches, hence ineffective retention processes, are leaky or dysfunctional.

Environmental factors such as rainfall amount and reliability, rainfall redistribution and soil type influence the formation and persistence of vegetation patches. Once established, patches tend to be self-sustaining as they progressively capture resources from surrounding areas and form 'islands of fertility' in a matrix of less fertile country. Perennial vegetation is more likely where soil moisture is more secure either through higher and/or more reliable rainfall (northern Australia) or run-on from adjacent areas (important in central Australia). Clay and sand soils may have a more uniform distribution of fine scale patches (tussock and hummock grasslands respectively) than loam soils where redistribution of resources may allow larger patches of trees and perennial grasses to coexist (e.g. mulga groves). Poorly managed grazing probably has a variable effect on patch persistence. For example, Mitchell grasslands on cracking clays are remarkably resilient to grazing, particularly in higher rainfall areas. Further, vegetation patches persist on many low-nutrient sandy soils because these areas are often avoided by stock (e.g. hummock, spinifex grasslands). Intermediate textured silty or loamy soils are probably most sensitive to patch decline from the grazing of palatable perennial vegetation, particularly where rainfall is erratic.

In central Australia rainfall is far lower and more variable than in northern Australia, where higher rainfall occurs in a distinctive wet-dry monsoonal pattern (Atlas of Australian Resources 1986). As rainfall amount and reliability declines, resource redistribution theory for arid lands predicts that the ratio of bare soil patches to vegetation patches will increase. This increase occurs because redistribution of runoff from bare areas into patches becomes more important as water availability decreases (see Ludwig *et al.* 1999). However, these authors found that this prediction did not seem to hold for sand and loam soils in higher rainfall zones in northern Australia.

In this article we further test this prediction using data from a large rainfall gradient that extends into the arid zone of central Australia. We used vegetation patch data acquired by aerial videography for different soil textures at points along a 'trans Australia transect' (TAT) from Oodnadatta in northern South Australia to the Victoria River District in the north of the Northern Territory. We relate various patch attributes derived from this imagery to rainfall and discuss how the characteristics of vegetation patches change along this environmental gradient. In the companion newsletter article, we describe a 'directional leakiness index' based on the cover and arrangement of patches in a landscape (Ludwig *et al.* 2002), and show how this index could be a useful remote sensing-based tool for monitoring change in landscape function under grazing.

Methods

Digital aerial video images were acquired at several locations between Kidman Springs (northern VRD) and Oodnadatta (Fig. 1) in 1998 and 1999. Where possible, sand, clay and loam soils were imaged in each region (Table 1) at pixel sizes between 20 cm and 50 cm. We were able to examine grazing effects on flight transects that included either an exclosure or intermittently grazed holding paddock, or included areas which were a considerable distance from water. In this article, we report on patch attributes where grazing was either minimal or absent.

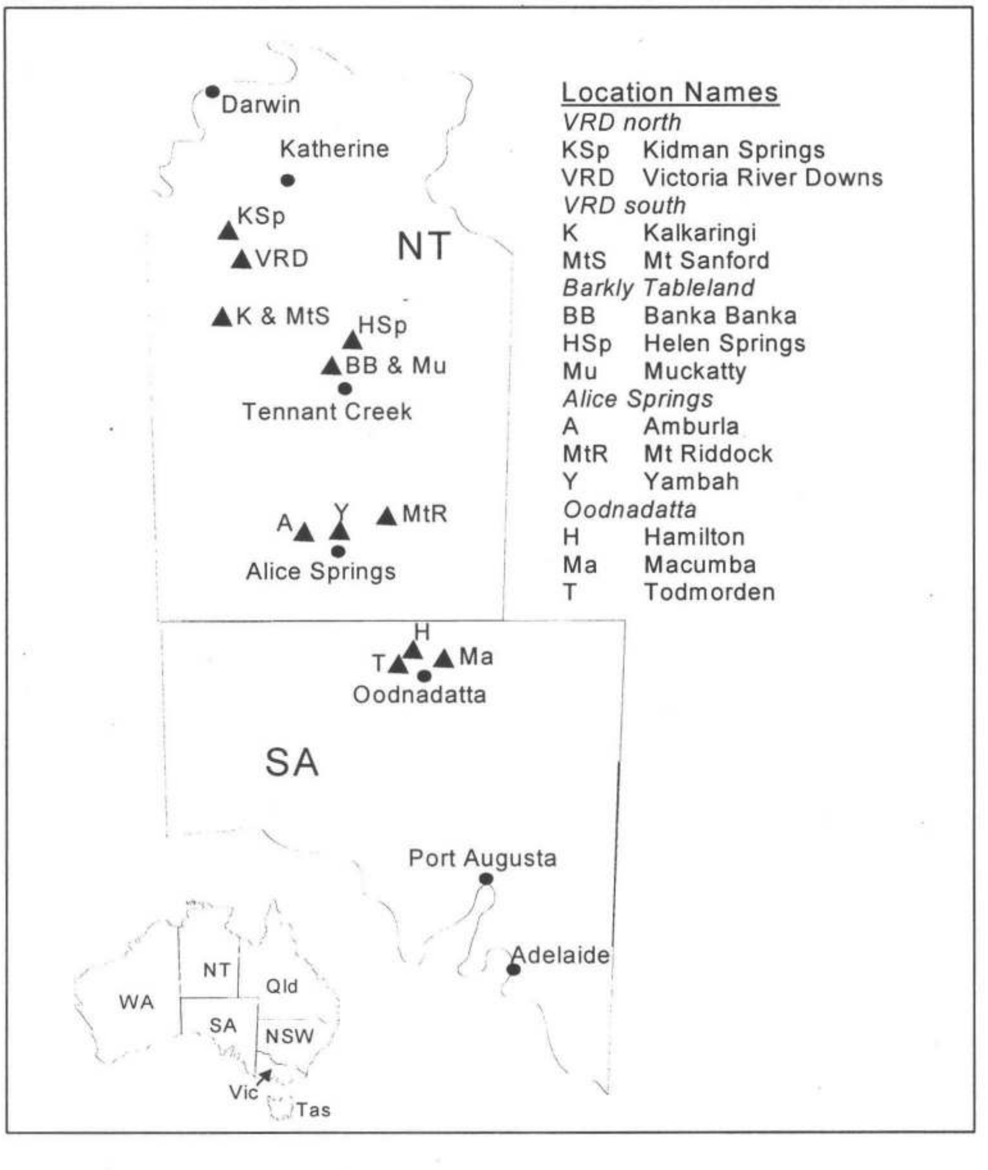

Figure 1. Main population centres (●) in relation to locations where aerial videography and rainfall records were acquired (▲) on our 'trans Australia transect' (see also Table 1).

Selected images were partitioned into patches of perennial vegetation (trees, shrubs and perennial herbage) and interpatches or fetches (bare soil, annual herbage and litter) using established techniques of sequential classification. Ground checking of the classified imagery was conducted at a number of locations (Table 1) to refine the class boundaries. Details of the video system, image correction procedures and sequential classification technique are described in Bastin *et al.* 1999.

Table 1. Locations of video flight transects and area analysed to determine patch characteristics at each location. Italicised areas indicate where ground truthing of classified imagery was conducted. (Note that the VRD south sand site was imaged at 1 m pixels.)

Region	Soil Texture		
	Clay	Loam	Sand
VRD north	Victoria River Downs *2.55 Ha*	Kidman Springs *3.43 Ha*	Not flown
VRD south	Mt Sanford Station *1.16 Ha*	Not flown	Mt Sanford Station 3.02 Ha
Barkly	Helen Springs Station 7.35 Ha	Muckatty Station 12.13 Ha	Muckatty Station 6.25 Ha
Alice Springs	Yambah Station *1.42 Ha*	Mt Riddock Station *3.66 Ha*	Amburla Station 3.54 Ha
Oodnadatta	Hamilton Station *2.74 Ha*	Todmorden Station *4.74 Ha*	Macumba Station *2.31 Ha*

Simple attributes of patch size and separation were calculated using the Spatial Analyst extension of ArcView. Where necessary, classified images were resampled to a standard pixel size of 50 cm prior to calculating these values. These data were then related to long-term annual rainfall (data obtained from the Bureau of Meteorology). Rainfall was analysed for Victoria River Downs (115 years), Kalkaringi (66 years), Banka Banka (44 years), Tennant Creek (126 years), Alice Springs (126 years) and Oodnadatta (60 years).

Results

Rainfall

Median annual rainfall increases from central to northern Australia (Fig. 2a) and its interannual variability, as indicated by its coefficient of variation, decreases. A further measure of rainfall variability is the return period of various sized rainfall events, which we calculate as the mean time in days separating rainfall events of specified minimum size falling within specified time periods. The average return period of increasingly larger events decreases from south to north (Fig. 2b). For example, the average return period of a 50 mm or greater rainfall event (with an event meaning no more than seven days between any set of rainfall recordings) is 108 days at Victoria River Downs Homestead, 163 days at Tennant Creek and 216 days at Alice Springs. Finally, the seasonality of rainfall markedly decreases inland (Fig. 2c) as the influence of the northern monsoon decreases.

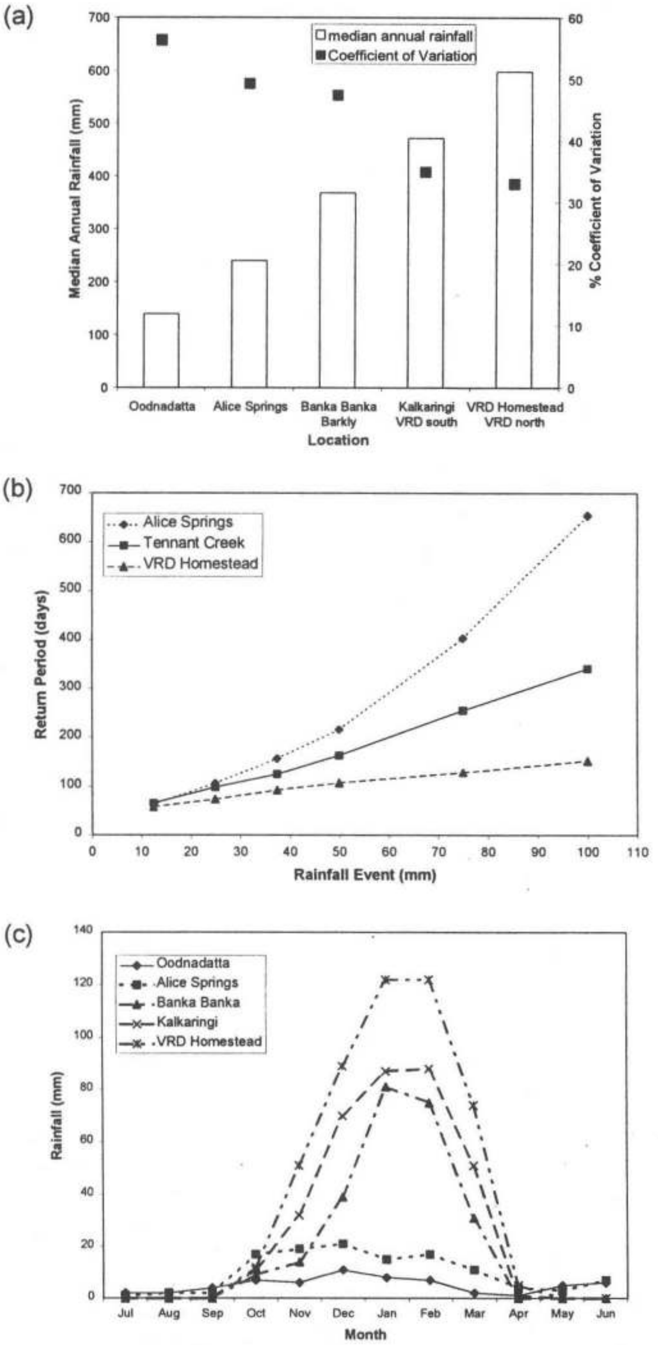

Figure 2. (a) Median annual rainfall and percentage coefficient of variation in median annual rainfall, (b) return period (days) of various sized rainfall events (where an "event" is defined as a period of rainfall with no more than seven contiguously dry days in this period) and (c) median monthly rainfall of selected recording stations.

Patch cover

The proportion of imagery covered with perennial vegetation increased with increasing median annual rainfall (Fig. 3). The spinifex sand sites at Alice Springs, Barkly and VRD south were all at various stages of post-fire recovery and this had an undetermined effect on the relationship between rainfall and patch cover (and other patch attributes described below).

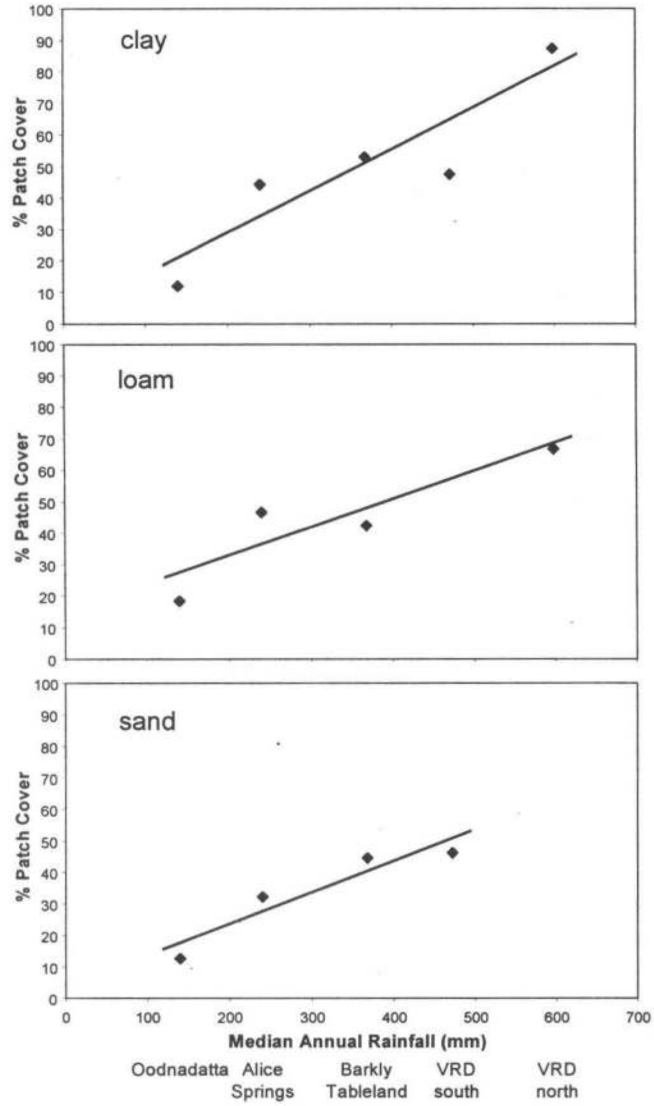

Figure 3. Percentage cover of vegetation patches on clay, loam and sand sites receiving different median annual rainfall.

Fetch to patch ratio

The ratio of the area of fetch to patch declined on all soil textures with increasing rainfall (Fig. 4). This decrease was most marked between Oodnadatta and Alice Springs, particularly for the clay and sand soils.

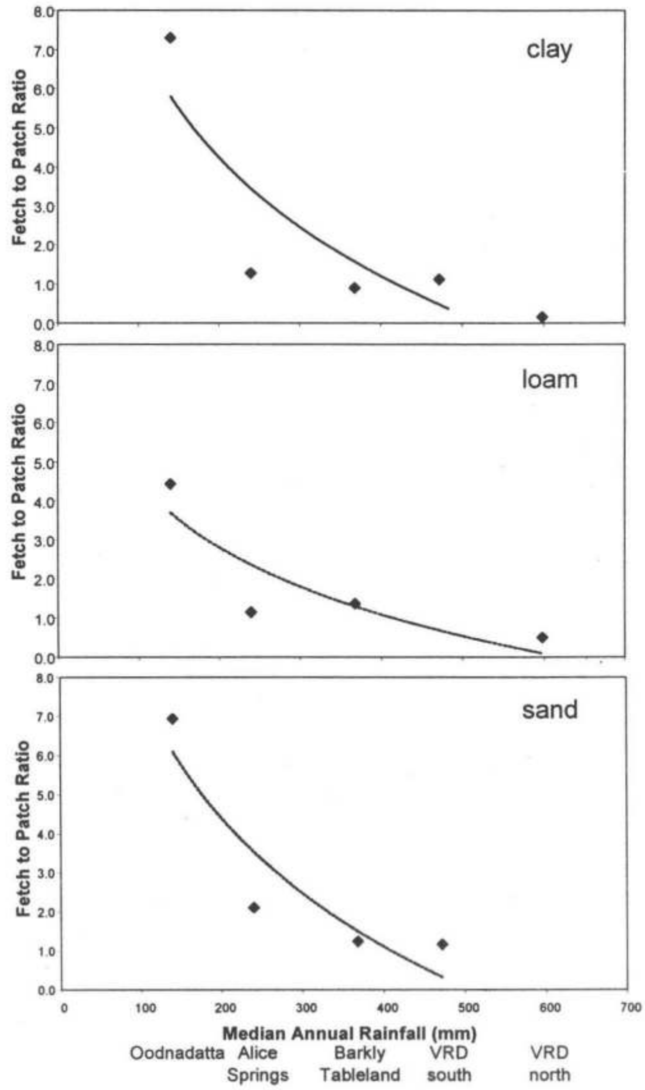

Figure 4. Ratio of fetch area to patch area on clay, loam and sand sites receiving different median annual rainfall.

Mean patch size

Mean patch size tended to increase with increasing median annual rainfall (Fig. 5). The VRD north clay site had a very large mean patch size and, by association, a low patch density (data not shown). This occurred because patch cover was high (Fig. 3) and at the resolution of the video imagery, many small patches had coalesced to form continuous patch cover. Mean patch size on loam increased substantially between Oodnadatta and Alice Springs with little change thereafter. The substantially larger patch size for the VRD south sand site partly resulted from an enlarged pixel size. We had flown this site at 1 m pixel resolution for a different purpose and subsequently included it in this study; it was then not possible to resolve patches smaller than 1 m^2. Excluding this site, there was a slight increase in mean patch size on sand sites between Oodnadatta and Barkly.

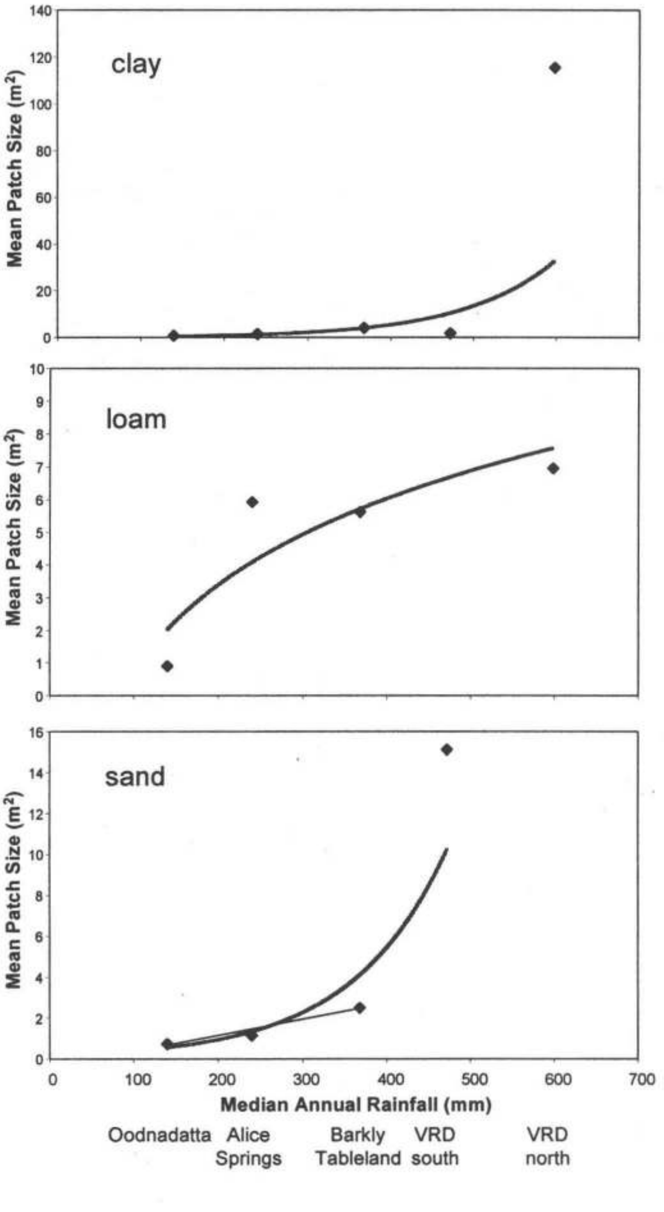

Figure 5. Mean size of vegetation patches on clay, loam and sand sites receiving different median annual rainfall.

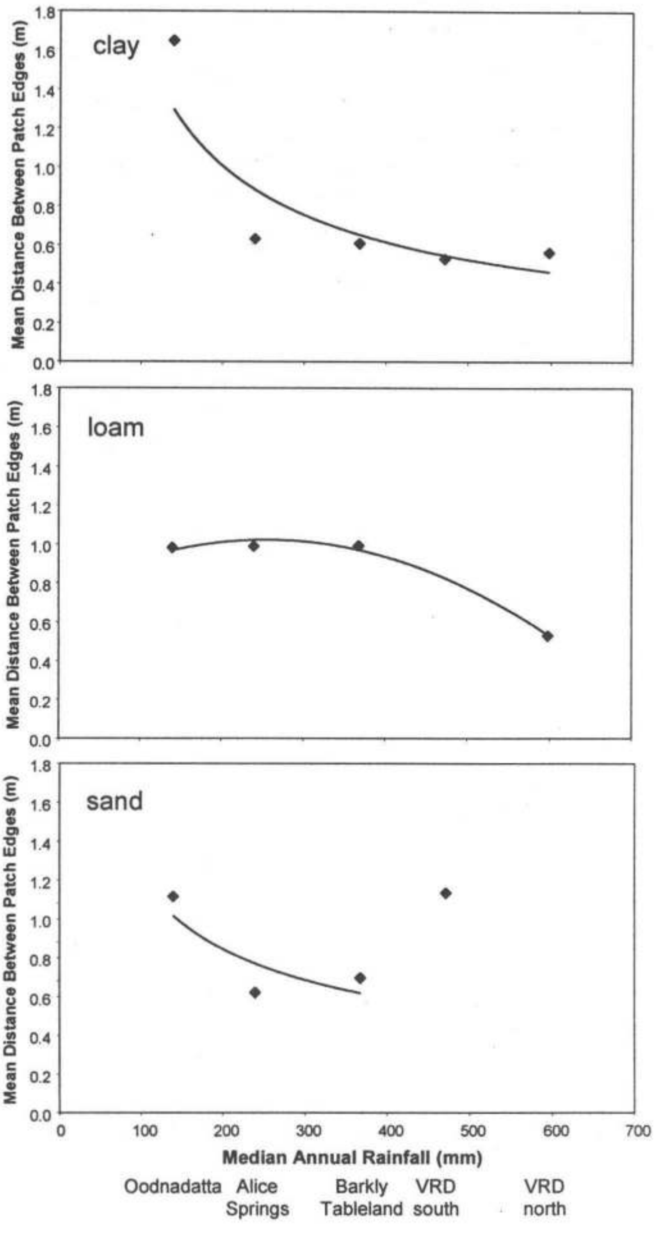

Figure 6. Mean distance between patch edges on clay, loam and sand sites receiving different median annual rainfall.

Separation of patch edges

The mean distance between patch edges varied with rainfall and soil type (Fig. 6). There was a sharp decrease in patch edge separation on clay sites between Oodnadatta and Alice Springs and little change thereafter on northern sites. Loam sites had similar patch separation at lower rainfalls but patches were closer together, on average, at the VRD north site. There was no clear trend for sand sites, although excluding the VRD south site because of its larger (1 m) pixel size suggested that patch separation decreased between Oodnadatta and Alice Springs and then remained similar with the higher rainfall of the Barkly site. Stage of vegetation recovery following fire was a probable further contributing factor to differences amongst sand sites.

Discussion

The cover and mean size of perennial vegetation patches increased with increasing median annual rainfall along our 'trans Australia transect' while the fetch-to-patch ratio decreased. Degree of patch separation was more variable but both the clay and sand sites had more dispersed patches at the lowest rainfall. The correspondence between median rainfall and measures of rainfall variability and seasonality (Fig. 1) suggest that similar relationships should exist between these patch attributes and rainfall reliability. That is, patch cover and patch size decrease and patch separation tends to increase as rainfall variability increases and seasonality decreases. At the broadest level of interpretation, these results confirm general knowledge that the amount of perennial vegetation decreases from northern to inland Australia as aridity increases.

At a more detailed level, the results seemingly contradict Ludwig *et al*.s' (1999) finding that "fine-scale vegetation patches **decline** in size and cover with **increasing** rainfall in Australian savannas". This could be due to a change in limiting resource for plant growth along our extended transect; i.e., nutrients possibly most limiting under plentiful wet-season rainfall in the tropical north, water more limiting in the arid interior. This supposition aside, there were a number of differences in the way data were collected and analysed in both studies that may explain this apparent conflict.

In their earlier study, Ludwig *et al.* (1999) collected vegetation data from 38 sites with sand, loam or clay soils extending from Banka Banka (368 mm median annual rainfall) to a site south east of Darwin (1406 mm). They measured the width and intercept length of fine-scale patches (<5 m in width) and the fetch between patches along line transects of 100-120 m length oriented down slope. They then presented their results in terms of fetch-to-patch ratio, mean fetch length and ground-layer patch cover (i.e. excluding trees and shrubs). Differences between the two studies include:

1. The rainfall gradient sampled. The earlier study extended into the wetter tropics whereas this study had some overlap but included the more arid interior of central Australia.
2. Lack of replication across soil textures at each rainfall regime in the current study with consequently reduced statistical power of our results.
3. Sample area and design. The earlier study measured relatively small, carefully stratified areas on the ground such that patch attributes were directly related to water flow and likely sediment redistribution. This study reports reconnaissance-level landscape statistics where resource redistribution is a factor but we have not attempted to partition its influence.
4. Resolution of measurement. The ground-based study had a resolution of 5 cm and patches were partitioned into woody layer and ground layer components. We used a 50 cm pixel size and combined the woody and perennial herbage layers because of our inability to "see" ground vegetation in video images whereit was concealed by tree canopies. Shadow cast by trees and shrubs further concealed part of the ground surface depending on woody cover and flying time through the day and year. We included shadow as 'patch' because it most likely concealed perennial vegetation but this undoubtedly over-estimated patch cover in some landscapes. It was not possible to ground truth all areas flown and there may be residual misclassification error in some video images analysed.
5. Reporting of results. The former study had a particular emphasis on specific elements of landscape function, particularly potential redistribution of resources (water and nutrients), at the relatively fine scale of smaller patches (<5 m width) within landscapes. We wanted to sample much larger, often remote, areas rapidly and relatively cheaply (hence our interest in aerial videography). Because we lacked detailed information about slope in the current study, our results for patch cover cannot be directly related to water flows, however, the ratio of bare area (fetch) to vegetation patch cover is likely to reflect general water redistribution processes in the landscapes we studied.

Rather than our results directly conflicting with the earlier findings of Ludwig *et al.* (1999), we argue that they present a coarser-resolution view of some of the same, and different, landscapes. We describe patch statistics for more coarsely defined patches over larger landscape areas without specific knowledge of the direction of resource flows.

Although we have no direct information on water and nutrient relationships within each landscape, we consider that our data provide some inferences about likely redistribution processes. At the scale of our measurements (up to 12 Ha), the small distances between larger patches on the wettest clay site suggest that there is very limited movement of resources through the landscape and consequently little leakage. At the other end of the rainfall gradient, patches are very much smaller and considerably further apart. The patches exist because water runs into gilgais that support saltbushes and Mitchell grass. Persistence of these perennials is presumably further assisted by capture of nutrients in any water-borne sediment. Gilgais retain some of the water within the gibber-strewn and gently sloping landscape but in intense rainfalls, variable amounts flow through (leak) to lower gidyea-lined creeks. Between Alice Springs and VRD south, the cracking clays imaged appear to support similar arrangements of tussock (mainly Mitchell) grasses that presumably have good capture and retention of water and nutrients within each landscape. In similar vein, the data for the loam soils suggest that water (and possibly nutrient) redistribution is increasingly important in maintaining patch structure as rainfall decreases and becomes more unreliable.

Notwithstanding the lack of replication, we fitted trend lines to the rainfall – patch data that provided additional insight into patch relationships with rainfall on different soil textures. We accept that these relationships lack predictive value because of the limited sampling conducted and thus have not shown regression equations. Patch cover appears to respond linearly to increasing median annual rainfall on at least the clay and loam soils. At the level of discrimination of the video imagery, mean patch size on clay soil increased rapidly at the highest rainfall because smaller patches had coalesced to form continuous cover. Patches tended to maintain their identity with increasing rainfall on loam soils and thus there was less dramatic increase in mean patch size. Mean patch size at the VRD south sand site suggested that this attribute also increased rapidly on sands with higher rainfall but we discount this trend because of our inability to discriminate patches between 0.25 and 1 m^2 at this site. The three southern sites on sand indicate that patches maintain their identity and increase slowly in size as rainfall increases. Stage of post-fire vegetation recovery is a further reason for caution in predicting ecological trend from our limited data.

As patch cover and patch size decrease with increasing aridity, it is logical to expect patches to be more widely dispersed in the landscape and the area of fetch potentially contributing to the maintenance of patches to increase; this theoretical relationship is illustrated in Fig. 2 in Ludwig et al. (1999), although their findings did not support this theoretical relation. By contrast, our data (Fig. 4) support this prediction that fetch-to-patch ratio increases with decreasing rainfall (amount and reliability). As expected from this result, mean patch size declines (Fig. 5) and patch edge separation (Fig. 6) increases markedly at the lowest end of the rainfall gradient.

High resolution remotely-sensed imagery offers potential benefits over ground-based methods for measuring and monitoring patch characteristics of rangeland vegetation. In a companion article, we describe how a directional leakiness index derived from such data may be useful for indicating landscape function based on a landscape's ability to retain (not leak) the water and nutrient resources required for plant growth.

Acknowledgements

We thank the owners and managers of the various cattle stations for allowing us to collect aerial videography and ground data at desired locations. Many of these people provided hospitality and helpful advice for which we are grateful. We thank Mark Stafford Smith and Trevor Hobbs for assistance in calculating rainfall return periods.

References

Atlas of Australian Resources, Climate, 3rd Series. Commonwealth of Australia, Canberra, 1986.

Bastin, G.N., Chewings, V.H, Pearce, G. and Pickup, G. (1999). Video – I see! Measuring rangeland vegetation with aerial videography. *Range Management Newsletter*, No. 99/2, 7-12.

Ludwig, J.A., Tongway, D.J., Eager, R.W., Williams, R.J. and Cook, G.D. (1999). Fine-scale vegetation patches decline in size and cover with increasing rainfall in Australian savannas. *Landscape Ecology*, **14**: 557-566.

Ludwig, J.A., Eager, R.W., Bastin, G.N., Chewings, V.H. and Liedloff, A.C., (2002). A leakiness index for assessing landscape function using remote-sensing. *Landscape Ecology*, in press.

Tongway, D. J. and Ludwig, J. A. (1997a). The conservation of water and nutrients within landscapes, Chapter 2. *In* J. Ludwig, D. Tongway, D. Freudenberger, J. Noble and K. Hodgkinson (Eds) *Landscape Ecology, Function and Management: Principles from Australia's Rangelands*. CSIRO Publishing, Melbourne, Australia. pp 13-22

Tongway, D. J. and Ludwig, J. A. (1997b). The nature of landscape dysfunction in rangelands, Chapter 5. *In* J. Ludwig, D. Tongway, D. Freudenberger, J. Noble and K. Hodgkinson (Eds) *Landscape Ecology, Function and Management: Principles from Australia's Rangelands*. CSIRO Publishing, Melbourne, Australia. pp 49-61.

MONITORING LANDSCAPE FUNCTION WITH REMOTELY-SENSED IMAGERY

Gary Bastin and Vanessa Chewings, CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs NT 0871
John Ludwig, Tropical Savannas CRC and CSIRO Sustainable Ecosystems, PO Box 780, Atherton Qld 4883
Robert Eager and Adam Liedloff, Tropical Savannas CRC and CSIRO Sustainable Ecosystems, PMB 44, Winnellie NT 0822
Robert Karfs, Northern Territory Department of Infrastructure, Planning and Environment, PO Box 30, Palmerston NT 0831

Introduction

Healthy savanna rangeland landscapes have been broadly defined as those that function to (1) conserve resources by retaining water, soil and nutrients, (2) provide food and shelter (habitat) for fauna, and (3) meet the material, aesthetic and spiritual needs of people having an interest in these rangelands (Whitehead *et al.* 2000). Those elements relating to resource conservation have been defined as 'landscape function' (see Ludwig *et al.* 1997). Assessment of ecosystem (including landscape) function was promoted as a component of monitoring the condition of biophysical resources in the Rangeland Monitoring theme of the National Land & Water Resources Audit (Watson 1999). The national recognition of the importance of this element of rangeland health builds on recent monitoring activities by various state and territory agencies as part of the Audit (e.g., Karfs *et al.* 2000).

How well landscapes specifically function to retain, not 'leak', water and soils is largely determined by the cover, number, size, shape and spatial pattern of perennial vegetation patches (i.e., trees, shrubs and perennial grasses). At the site level, ground-based techniques are well established for landscape function analysis (Ludwig *et al.* 1997, Karfs *et al.* 2000). In a preceding article (Bastin *et al.* this issue), we described broad trends in the cover, size and separation of patches along a rainfall gradient from Oodnadatta in central Australia to the Victoria River District in northern Australia. This information was obtained from aerial videography. As an extension of that work, we have investigated the role of high-resolution remotely-sensed imagery in providing a belt sample of vegetation patches, thereby increasing the scale of measurement from that of existing ground-based line transects. In this article, we describe the use of aerial videography to determine a directional leakiness index, which we see as a potentially useful way of indicating landscape function (resource retention) over broader areas.

John Ludwig and his Darwin colleagues developed the index and further detail is available in a forthcoming paper in *Landscape Ecology*.

Directional Leakiness Index

The Directional Leakiness Index (DLI) assumes that the direction of resource flow across a landscape is known and that a remotely-sensed (e.g. video) image of the landscape can be rotated so that the direction of flow is down columns of the image. The image is initially classified into patches and interpatches (ie., non-patch pixels, Fig. 1). DLI then measures the relative leakiness of a landscape, that is, how likely it is to lose resources.

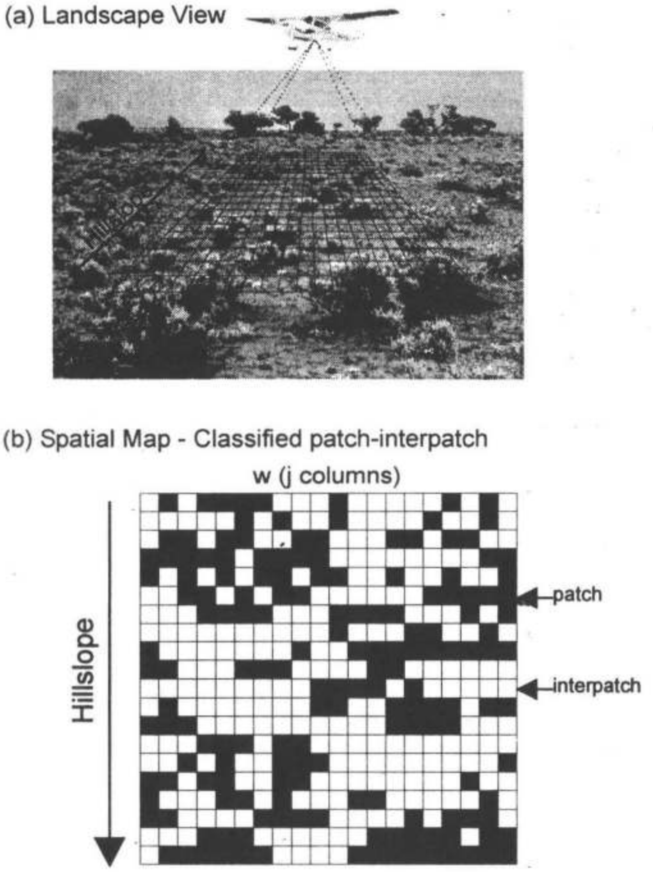

Figure 1. Schematic representation of a hillslope landscape: (a) video image and (b) image classified into either flow-obstructing patches or interpatches.

Three terms are needed to calculate a DLI value for a landscape (see Ludwig *et al.* 2002 for details):

1. L_{obs}, which is the sum of squares of the observed distances (in metres) of all interpatch lengths in all columns of the classified image. L_{obs} is scaled to a standard area (eg., 1 ha for the coverage typically provided by aerial videography) using proportional image dimensions.

2. L_{max}, which is the maximum leakiness for the image, and is computed as the square of interpatch distances for a landscape with no obstructing patches. For a standard 1 ha map at a resolution of 1 m, $L_{max} = 1{,}000{,}000$.

3. L_{min}, which is the minimum leakiness for a reference or undisturbed area. This can either be computed assuming that the image is totally covered with obstructions (ie., no interpatches, hence, $L_{min} = 0$) or L_{min} can be set to a value > 0 determined from a suitable reference area.

Given these terms, the directional leakiness index, DLI, is computed as:

$$DLI = 1 - [(L_{max} - L_{obs})/(L_{max} - L_{min})]^{k}.$$

DLI values range between 1 (= totally leaky) and 0 (non-leaky). When plotted against percent patch cover, DLI takes the form of a decay curve with the parameter k determining the steepness of the curve. For $k = 5$, DLI values provide a good fit with runoff and erosion data from numerous field studies.

When the direction of resource flows across a landscape is unknown, a variant of DLI, the multi-directional leakiness index (MDLI) can be computed. Here, it is assumed that the overall flow patterns may be expressed as a combination of those that would occur if flow was trending down columns or across rows of pixels in the image. First, a DLI for columns, DLI_c, is computed, as above, and then a DLI_r is determined for rows using analogous computations, with MDLI taken as their average:

$$MDLI = (DLI_c + DLI_r)/2.$$

MDLI values also range between 0 (ie., no leakiness) and 1 (totally leaky).

Application of DLI and MDLI

The utility of DLI and MDLI for assessing the relative leakiness of rangeland landscapes was initially tested by using classified video imagery of three savanna sites at Kidman Springs in the Victoria River District. Site KS1 was located near a bore and had large areas of bare soil and only a few patches of perennial vegetation, mostly spiny shrubs (Fig. 2a). Site KS3 was 1.4 km from water and had a moderate cover of mostly low annual grasses. Site KS5 was within an exclosure (ungrazed for 25 years) and had a high cover of perennial grass patches and some shrubs.

In this example, DLI and MDLI values were similar and only MDLI is reported. MDLI for the site closest to water (KS1) was much greater than that for the site 1.4 km from water (KS3) and for the exclosure site (KS5, Fig. 2b). These results indicate that, as expected, KS1 is potentially far more leaky than the other two sites. Importantly, the MDLI values allowed each site to be positioned along a continuum of resource conservation (Fig. 2c).

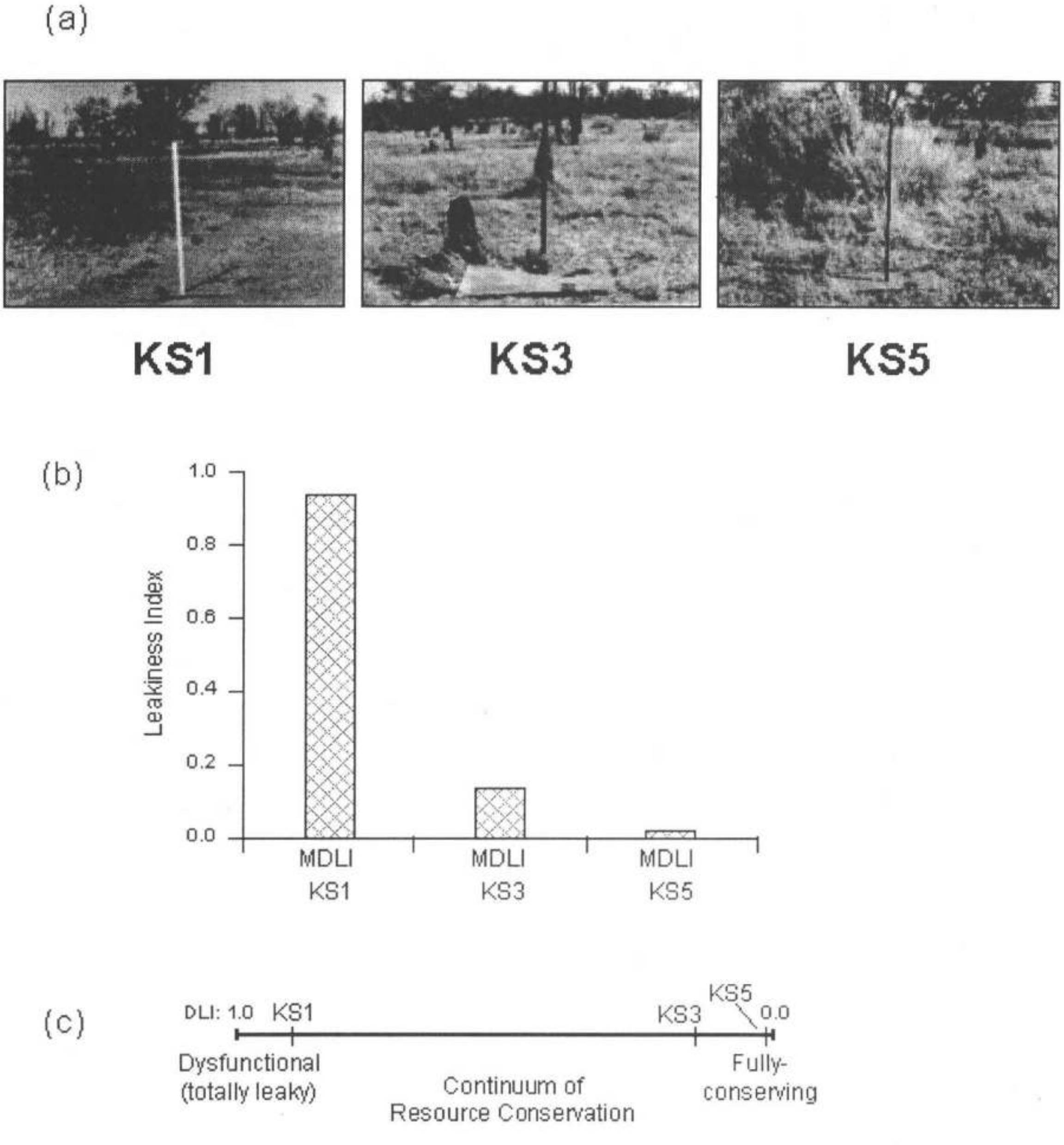

Figure 2. Example of applying the multi-directional leakiness index to a savanna landscape: (a) photographs of three sites located on Kidman Springs that differ in patch attributes, (b) MDLI values and (c) the position of these three sites along a continuum of resource conservation based on MDLI. (Note: in this example, DLI and MDLI values were very similar.)

DLI and Monitoring Landscape Function

Both DLI and its variant, MDLI, are derived from basic principles of landscape patterns, processes and functions (Ludwig *et al.* 2002). We argue that both indices are intuitively sensible and conceptually simple to understand in terms of how landscape patch structures potentially operate to retain water and soil resources that are vital to the functioning of rangeland ecosystems. The ability of both leakiness indices to position sites on a continuum that is related to landscape function, combined with their robustness when compared against other landscape metrics or indices (Bastin *et al.* submitted), means that they should have potential for monitoring grazing impact. Such a monitoring program might be implemented by acquiring and suitably processing remotely sensed images at appropriate time intervals (e.g. Karfs *et al.* 2000) to calculate leakiness index values for selected landscapes.

That such assessments are related to the cover and arrangement of vegetation patches derived from high-resolution remotely sensed data means that they provide more detailed information about fine-scale landscape processes than is the case with satellite-based monitoring methods that are now being implemented. These latter methods include landscape cover change analysis in northern Australia (Karfs *et al.* 2000) and grazing gradient methods in central Australia (Brook *et al.* 2001), both of which use Landsat TM imagery of 30 m pixel resolution.

The down-side of the higher resolution, fine-scale analyses using DLI and MDLI is that data acquisition costs and the immense volume of data required will mitigate against analysing large areas. A sensible strategy could be to routinely monitor grazing impact at the regional scale using established methods based on Landsat TM imagery and then target identified areas of change with more detailed analysis of landscape function using higher resolution imagery and the leakiness index. Ground-based validation is essential with both methods.

One requirement in implementing the leakiness index as a fine-scale monitoring tool will be to suitably adjust DLI (or MDLI) values according to appropriate minimum leakiness (ie., L_{min}) levels for each environmental setting. For example, our preceding article showed how patches of all sizes become smaller and further apart as aridity increases from northern to inland Australia. One approach to making landscapes from different regions and occurring on different soils more comparable would be to scale DLI, hence MDLI, to that for reference landscapes in their undisturbed state (see Ludwig *et al.* 2002). In Fig. 3, we show the raw (ie., $L_{min} = 0$) and adjusted MDLI values of clay sites close to water for various locations along our trans Australia transect (see preceding article). Adjustment is based on the L_{min} of adjacent, relatively intact, areas. The reduction in MDLI due to weighting L_{min} in each case is directly related to the patch characteristics of the reference area and therefore the effect is variable across locations. Appropriately scaling DLI (and MDLI) with L_{min} should allow more valid comparison of sites and landscapes. For example, the adjusted index value of the Alice Springs site is considerably reduced compared with the Barkly Tableland site, whereas their raw MDLI were similar. These adjustments to DLI should also more strongly relate this index to other attributes of ecosystem functioning in arid and semi-arid lands such as rainfall use efficiency (RUE, Le Houréou 1984).

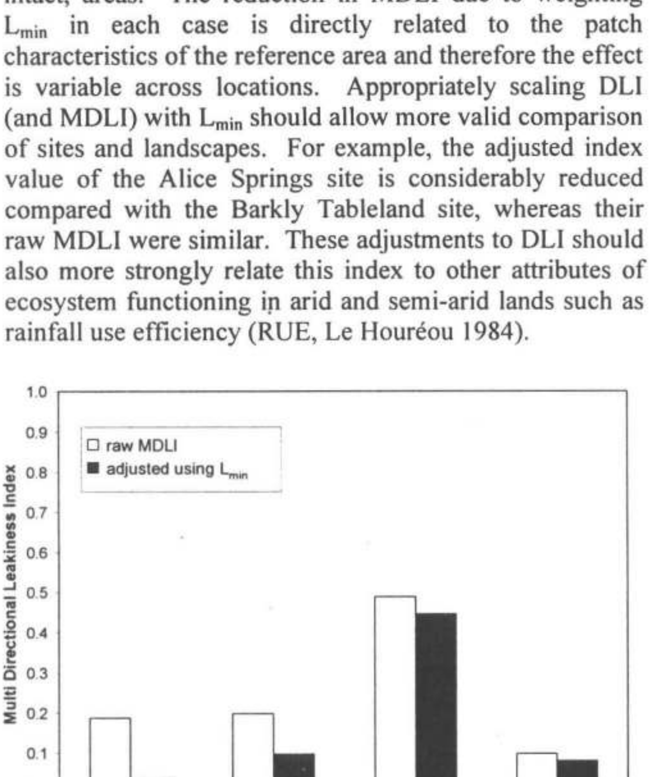

Figure 3. Raw and adjusted MDLI of grazed clay sites at various locations along our trans Australian transect. In each case, L_{min} was adjusted using the DLI value of a nearby reference area.

Potential of Future Satellites

Routine monitoring of landscape function with a directional leakiness index will likely require the analysis of very high resolution satellite data rather than aerial videography. Aerial videography has been a very effective tool for sampling small areas of the rangelands. Satellites of course provide routine and broad-area coverage. The IKONOS satellite may already supply suitable data with its 4 m multispectral capacity and planned satellites carrying hyperspectral sensors may provide expanded choice for data analysis in the future.

Although the 'hyper-spatial' capacity of IKONOS is appealing, its 4 m resolution may still impose some limitations on one's ability to discriminate fine-scale vegetation patches. For example, in cracking clay grasslands, individual tussock grasses constitute functioning patches. While it is possible to distinguish most tussocks, hence patches, in 20 cm video imagery, the task becomes more difficult in 50 cm and 1 m imagery. At 4 m pixel resolution, patch discrimination will likely be at the level of groups of tussock grasses with many scattered and isolated tussocks being inappropriately classified as interpatches. Where effectively functioning patches are much larger (eg., mulga groves in central Australia), pixel resolution of very high resolution satellite data should not be as critical in accurately distinguishing such patches. We are currently testing remotely-sensed data at incremental scales to determine where spatial resolution becomes critically limiting in accurately determining increasing leakiness, and hence loss of function, in selected landscapes.

The hyperspectral qualities of 'new generation' satellite data may partly compensate for the limitations imposed by pixel size in adequately discriminating functioning patches in some landscapes. The key requirement will be to suitably 'unmix' patches and fetches as components of enlarged pixels. We currently have access to Hyperion imagery (228 bands in the spectral range 0.4 to 2.5 μm, see http://eo1.gsfc.nasa.gov/Technology/Hyperion.html) and are exploring the potential to resolve patches and fetches within its 30 m pixels.

Conclusion

Our directional leakiness index DLI, and its counterpart MDLI, have the ability to rank sites on a continuum of resource conservation that is related to landscape functionality. Both indices are potentially useful for monitoring grazing-related changes in soil and vegetation condition through time within paddocks or parts of paddocks. Development to date has been based on the analysis of aerial videography. Further work is required to determine whether vegetation patches can be suitably discriminated in satellite imagery of very high spatial resolution and whether the additional information provided by hyperspectral data will allow sub-pixel components of vegetation patches to be suitably identified.

References

Bastin, G.N., Ludwig, J.A., Eager, R.W., Chewings, V.H. and Liedloff, A.C. (2002). Indicators of Landscape Function: Comparing Patchiness Metrics using Remotely-Sensed Data from Rangelands. *Ecological Indicators, in press.*

Brook, A. and Fleming, M. (2001). Benefits of a grazing gradient approach for rangeland monitoring in northern South Australia. *Range Management Newsl*etter, No. 01/3, 1-6.

Karfs, R., Applegate, R., Fisher, R., Lynch, D., Mullin, D., Novelly, P., Peel, L., Richardson, K., Thomas, P. and Wallace, J. (2000). *Regional land condition and trend assessment in tropical savannas: The Audit Rangeland Implementation Project Final Report.* National Land and Water Resources Audit, Canberra. 55 pp.

Le Houréou, H.N. (1984). Rain use efficiency: a unifying concept in arid-land ecology. *Journal of Arid Environments,* 7: 41-46.

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

Ludwig, J.A., Eager, R.W., Bastin, G.N., Chewings, V.H. and Liedloff, A.C. (2002). A leakiness index for assessing landscape function using remote-sensing. *Landscape Ecology*, in press.

Watson, I. (1999). Towards a national rangeland monitoring program. *Range. Management Newsetter*, No. 99/2, 6-8.

Whitehead, P.J., Woinarski, J., Jacklyn, P, Fell, D. and Williams, D. 2000. Defining and measuring the health of savanna landscapes: a north Australian perspective. Published by the Tropical Savannas Cooperative Research Centre, Northern Territory University, Darwin.

THE IMPACT OF RABBIT GRAZING ON THE SUCKER RECRUITMENT OF THE THREATENED SPECIES PURPLE-WOOD WATTLE (*Acacia carnei*).

David Lord, 'Thackaringa' Station, via Broken Hill, NSW, 2880.

Introduction

Background

Previous studies have suggested that the regeneration of the Australian perennial flora can be influenced by rabbit grazing. Indeed, Cooke (1991) found that in densities of only one rabbit per hectare, rabbits were able to prevent the regeneration of some plant species.

Anecdotal evidence suggests that rabbits have influenced the native vegetation in the Western Division of New South Wales. Rabbits have been present in this area for more than a century, reaching the Broken Hill region in the early 1880's and running unchecked for seventy years (Lord 1994). Despite huge efforts by the land managers of the day, early attempts to control the rabbits failed and severe overgrazing from rabbits continued until 1950 with the release of myxomatosis (Lord 1999). Anecdotal observations suggest there was no regeneration of many perennial native species from the period 1880 to 1950 in this region.

> "From the period 1880/90 to 1950 no young trees grew except prickly wattle *(Acacia victoriae)* and a few turpentine *(Eremophila sturtii*). After 1950, emu bush (*Eremophila longifolia*), sandalwood (*Eremophila platycarpum*), spotted fuschia (*Eremophila maculata*), mulga (*Acacia aneura*), nelia (*Acacia loderi*), quandong (*Santalum acuminatum*), bullock bush (*Heterodendrum oleifoluim*), black bluebush (*Maireana pyramidata*), hop bush (*Dodonaea attenuata*) and native pine (*Callitris columellaris*) all regenerated." (A. Bartholemaeus pers. comm.).

While the decline of rabbits following myxomatosis is likely to have influenced the recovery of perennial native species, two other major factors are likely to have contributed. These include:

- Polythene pipe lines, which allowed stock to be spread more evenly over the land; and
- Motor transport of livestock, which allows the movement of livestock at will. Previously, when dry periods occurred, managers often could not move stock out as the stock route itself would be drought stricken (Lord 1999).

Rabbit Calicivirus Disease (RCD) was first confirmed in the district on the 13 November 1995. Eighty percent of rabbits died within the first 10 days and another 15% over the following six weeks (myxomatosis also had a presence; Lord, 1999). At this time, my observations indicated that following useful November rainfall, there was major regeneration of many native perennial plant species. Despite the flourishing of some species, however, a significant number of these plants were lost to grazing by the remnant rabbit population (which was less than 10% of the pre RCD level) suggesting that even at low numbers rabbits may still influence recruitment in some species.

Aims of the study

This study investigated the effect of the rabbit, post RCD, on the level of sucker recruitment of the Australian rangeland perennial species, *Acacia carnei* (Purple-wood wattle). This species was chosen as a demonstrative species: it is hoped that the observations made may relate to other similar perennial species.

Methods

Study Area

The study sites were located on Thackaringa Station, approximately 40 km west of Broken Hill, New South Wales, near the border of South Australia (S 32 04 176, E 141 00 750).

The area is classified as semi-arid. The climate is one of low, aseasonal and variable rainfall with an average of 180 mm received annually. Over an 86 year period 62 % of the rainfall for the Broken Hill region was below average, the average being punctuated by some large wet years. Summers are hot, with common extended periods of temperatures over 40° C. Winters are cool (Scholz 1995).

The Landsystems on 'Thackaringa' include the Barrier, Nine Mile and Mundi landsystems. Red texture-contrast soils predominate across these landsystems although there are some areas of brown soils and sands. The vegetation includes sparse mulga (*Acacia aneura*) and prickly wattle (*A. victoriae*) in the overstorey and commonly chenopods such as pearl bluebush (*Maireana sedifolia*), black bluebush (*M. pyramidata*), low bluebush (*M. astrotricha*) and bladder saltbush (*Atriplex vesicaria*) in the understorey (Walker 1991).

Study Species

Acacia carnei is a small shrub or tree growing to 4 metres in height on sand dunes, level sandy sites or alluvial and aeolian accumulations along watercourses. It is limited to the Broken Hill region of New South Wales and the north east pastoral zone of South Australia (Cunningham *et al.* 1992).

A. carnei is a long-lived species: mature trees may be from 180 to 300 years old. The species flowers in autumn, winter and spring, however flowering is very infrequent as it depends on rainfall. Generally seed viability is very low and seedling recruitments are rare. Previous work has suggested that the production of vegetative suckers is more common, however these are generally lost to grazing by rabbits. Rabbits not only prevent regeneration, but they actively build warrens under adult plants, which may cause the plants to collapse and die (Auld 1992). *A. carnei* has a vulnerable status according to Schedule 2 of the Threatened Species Conservation Act 1995.

Trial Design

Colonies of *A. carnei* occur at numerous locations on Thackaringa Station. However, most of these sites have shown only limited signs of recruitment over the past one hundred years or greater and are therefore made up of only mature trees. There are only one or two instances where there is more than one age structure within each colony. In these cases there are two age structures, the younger trees being a little over 1 metre in height (the combination of events that have allowed for this more recent regeneration is not fully understood). At the commencement of the trial, all the selected colonies contained only large mature trees as these were only colonies covering sufficient area.

Three *A. carnei* sites were selected in Montana, Cow and Quarry paddocks. At each of these sites the trial plots were strategically placed around a mature stand of *A. carnei* trees so that sucker recruitment could be monitored.

Three grazing treatments were used:
1. Total Exclosure – which excludes all grazers. The fence was constructed out of wire netting and a top barbwire and rabbit infestations within the plots were eradicated;
2. Partial Exclosure – which excludes all grazers except rabbits. The fence has been constructed with hinge joint fabricated fencing with a top barbwire, which allows rabbits only to pass in and out; and
3. Control – which is open to all grazers, including rabbits, kangaroos and livestock (sheep and cattle).

Each treatment consisted of a plot of around one hectare with specialised fencing for the partial and total exclosure treatments. Grazing treatments within the trial area were randomly allocated within the stand of *A. carnei*. In the total exclosure treatment plots rabbit infestation was eradicated.

The trial was set up in August 1998. An initial count of *A. carnei* seedlings was conducted, and progressive counts to monitor sucker recruitment were carried out at six and twelve months. Each sucker counted was pegged to alleviate any duplication when counting and for photography purposes to illustrate the recruitment of suckers. Counting and plotting of sucker recruitment was mapped to scale of the plot area. At the time of the fence construction no suckers were evident. By the time initial sucker count commenced, a lag of some three weeks after fencing was completed, a substantial number of suckers had appeared in the total exclosure plots.

In the five weeks spent setting up the sites and doing the initial counts no rabbit were seen, although some evidence of their presence was observed. As all sites contained rabbit warrens, rabbit eradication was necessary in the total exclosure plots. This was successful in the Quarry and Cow Paddock sites. It proved very difficult in the Montana site, however, taking some two months to finally eradicate the rabbits using various methods.

The trial plots did vary slightly in size to fit in with the A. *carnei* plants. For example, the Quarry paddock total exclosure plot was 90 m x 100 m; most other sites were 90 m x 90 m. To be consistent, measurements were made from areas 8,100 m^2 in size.

Statistical Analysis

The trial tests the following null hypothesis: Rabbit grazing has no significant impact on the sucker recruitment of *Acacia carnei*.

Percent increase in sucker recruitment was calculated for each treatment plot. The mean was calculated for each grazing treatment over the three repetitions at both six and twelve months. The subsequent grazing treatment data was then used to test the null hypothesis using analysis of variance.

Results

Figure 1 illustrates the observed differences between grazing treatments on sucker recruitment of *A. carnei* on Thackaringa Station. The illustration clearly shows the positive effect in sucker recruitment of the total exclosure in comparison to the partial exclosure and control grazing treatments.

No significant differences were found between grazing treatments at 6 months (P>10%). At 12 months, percent increase in sucker recruitment was significantly greater in the total exclosure treatment than both the partial exclosure and control grazing treatments (2.5%>P>1%).

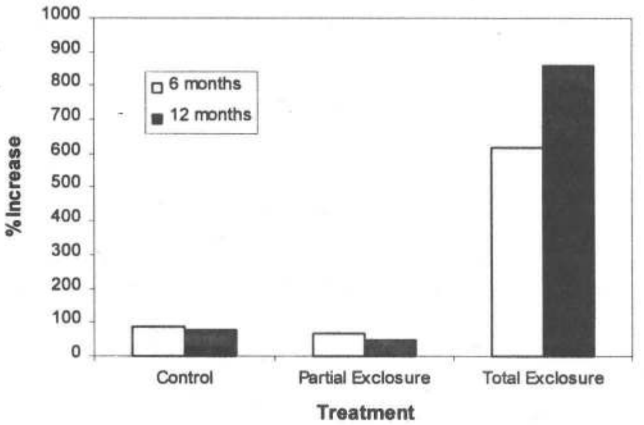

Figure 1. Percent increase in sucker recruitment of A. carnei on Thackaringa in response to three grazing treatments.

Discussion

During the observation period, sucker recruitment did occur in all treatment plots including the control areas and partial exclosures. The results indicate, however, that sucker recruitment was greater in the total exclosure plots. This strongly suggests that rabbit grazing does lead to decreased sucker survival.

Previous anecdotal observations of *A. carnei* sucker recruitment from November 1995 (immediately after the arrival of RCD) suggested that no suckers had survived. It is somewhat surprising, therefore, that there appeared to be some sucker survival in the control and partial exclosure plots during this study. If one looks carefully at the "maps" from the these plots, however, it can be seen that these suckers are, in many instances, different plants from those counted six months previously. One would assume that all suckers in the partial exclosure and control plots would be grazed off in time unless they manage to reach a stage where, with maturity, the leaves become less palatable to the rabbits. .

It should also be mentioned that a good deal of difficulty was encountered eradicating the rabbits from the total exclosure at the Montana paddock site. After three initial "Rid a Rabbit" treatments, a combination of methods was then used to get the remaining rabbits. When some of those remaining in the total exclosure plots had their grazing range limited by the fencing, they were observed readily. This led to some ten or more being shot or trapped. The exclosure was also treated with 1080 oats, after which time no more rabbits were observed. Unfortunately, this process took two months and in that time the rabbits did unprecedented damage as they became more stressed for food. Of the 58 suckers that were counted in the initial count on 18 August 1998 all were nearly grazed back to ground level.

Additionally, a kangaroo was also present in the total exclosure plot at the Cow Paddock site for an unknown period. A number of juvenile plants showed signs of grazing at the time of the February count. This would have influenced the count and thus would explain the loss from 202 suckers on 9/2/99 to 181 on 31/8/99. It is not considered that a rabbit caused the damage as a close watch has been kept on the fence and we are confident that it has been maintained in a rabbit proof state at all times. There is however some stretching of the netting from the inside which is consistent with a kangaroo hitting it in an attempt to get out. It appeared to have been a large kangaroo as the fence was 1.2 metres high and had a strand of barbwire to prevent cattle access. The kangaroo had cleanly cleared the fence on the way in and after one attempt to break had cleared the fence cleanly on exit.

The partial exclosures at both the Quarry and Cow Paddock sites recorded low numbers of plants at all countings. This was not because of any bias or inconsistencies in the sites, but because it is apparent that there is slightly more rabbit activity in those areas even though at each site the control, partial exclosure and total exclosure are all within approximately 100 metres of each other.

Finally, one of the most interesting observations made on Thackaringa since RCD swept through is how little rain appears to be needed to germinate and support the native plants. Such anecdotal observations have been supported by this study because as the rainfall charts in Figure 2 show there was little rainfall at any of the study sites (this was also combined with an intensely hot summer). Those in the community who are old enough to remember maintain that the current drought is equal to the great drought of 1940-44. They qualify that by saying the country is in much better heart because of the previously mentioned tools; polypipe, myxomatosis and RCD, and motor transport of livestock.

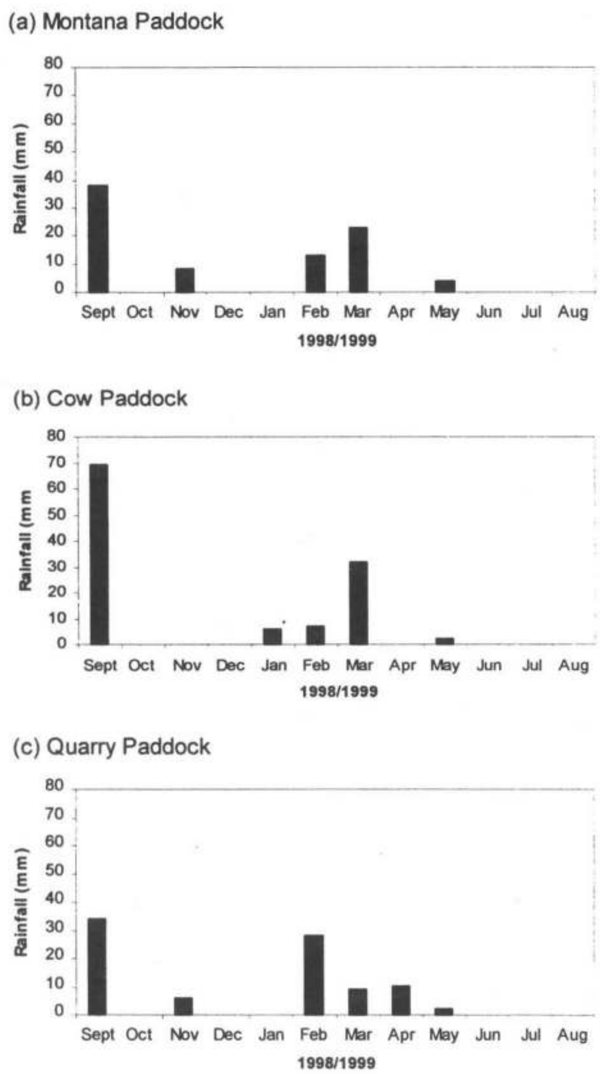

Figure 2. Monthly rainfall in the (a) Montana, (b) Cow and (c) Quarry paddocks from September 1998 to August 1999. The average annual rainfall for Thackaringa station is around 180 mm.

Conclusion

This study demonstrates that even at low numbers rabbits are able to prevent successful recruitment of *A. carnei.* Furthermore, the observations clearly support Dr Brian Cooke's work that suggests that less than one rabbit per hectare is sufficient to prevent recruitment of species (Cooke 1991).

Given the results of this trial, it is not difficult to assume that rabbits may be significantly influencing the recruitment of a number of plant species on Thackaringa. Thackaringa has an average warren density of 0.47 warrens per hectare; before RCD there would be anything up to 50 or 60 rabbits living in a warren. Post RCD, there are still an estimated 26000 active warrens on Thackaringa. With this rabbit activity, it is likely that there would only be a very limited opportunity for recruitment to occur.

This paper supports my previous suggestion that rabbits have been grossly underestimated in their effects on Australian flora and fauna and their impact has been masked by other issues such as a lack of understanding of a foreign environment by the first white land managers (Lord 1999). I still believe that further research and biodiversity studies are required to fully determine the impact rabbits are having on vegetation and wildlife.

Most importantly, there is a need for a continued effort to reduce rabbit populations by other methods currently available, such as habitat destruction. Additionally, while current biological controls have provided an advantage by substantially reducing rabbit numbers, there is also a need to continue to research new biological control agents. This is a very rare opportunity and unfortunately it is not known how long this advantage will be available.

References

Auld, T. (1992). *The Impact of Grazing on Regeneration of the Shrub Acacia carnei in Arid Australia.* Biological Conservation **65**: 165-176.

Cooke, B. (1991). *Rabbits. Indefensible on Any Grounds.* Search. **22**: 193-194.

Cunningham, G. M., Mulham, W. E., Milthorpe, P.L., and Leigh, J.H. (1992). *Plants of Western New South Wales.* Butterworth-Heinemann, North Ryde, NSW.

Lord, D. A. (1994). *Rangeland Management Practices to Achieve Sustainability.* Proceedings of the National Landcare Conference 1994.

Lord D. A. (1999). *Rabbits and Total Grazing Pressure - a Rangeland Manager's Perspective.* Proceedings VI International Rangelands Congress 1999

Scholz, G. (1995). *A Practical Guide to Rangeland Revegetation in Western New South Wales: Using Native Grasses.* Technical Report No. 33. NSW Department of Land and Water Conservation.

Walker, P.J. (comp.) (1991). *Land Systems of Western New South Wales.* Technical Report No. 25. Soil Conservation Service of NSW.

REPORT FROM COUNCIL

Lachlan Pegler, Communications Officer ARS, PO Box 224 Charleville Q 4470

The Officers of the Council of the society meet on a three-monthly basis to discuss and set direction on issues of importance to the society. The Council met on the 7th of February and discussed a range of relevant issues including:

- The upcoming ARS Kalgoorlie conference, with particular reference to the need to gain further sponsorship. Any members who can assist in this regard please contact any Officers of the society, or the organising committee.

- The Conference Committee were congratulated on the new website (www.austrangesoc.com.au). This site has already proved to be very successful in disseminating information about the Kalgoorlie Conference, and will be regularly modified into the future.

- The Membership Services Committee reported on initiatives to send introductory letters to appropriate graduating agricultural and natural systems students.

They also sought feedback on the development and use of policy statements by the Society. The Council voted to reject the proposal to develop policy statements as it was deemed too difficult to represent a unified view on issues when the Society is composed of such a diverse membership.

The Membership Committee has proposed a prize of one years ARS membership for the best Newsletter article each year. So get writing those interesting articles for the next issue!

- The Business Plan 2001-2005 has been reviewed once again, with the only major amendments being a review of the roles of the various Officers of the Society. Copies of the revised Plan are available from any Officer of the Society.

- The treasurer has been endeavouring to simplify the account structure of the society, and has closed a number of bank accounts that were opened across the countryside for various purposes. There is still concern at the slide in members, and although the Society has relatively healthy finances, it does not look good long-term without action.

- The business address of the Society has been changed. It is now as follows:

  Australian Rangeland Society
  PO Box 4082
  Norwood South SA 5067

This address should be used for all official correspondence with the Society. In future it is hoped to change the business address to that of the accounting firm to give greater permanency.

- Following discussion of the virtually universal dislike for both the logo and slogan of the Society, there was a proposal for a competition to review the logo and slogan (see article in this issue).

- The final important topic was to call for expressions of interest in hosting the next conference (see article in this issue).

NOTICE OF ANNUAL GENERAL MEETING

Merri Tothill, President ARS, PO Box 357, Port Augusta SA 5700

The 2002 Annual General Meeting of the Australian Rangeland Society will be held at 9.30am (CST) on **Tuesday 21st May 2002** at Pastoral Program, PIRSA, Level 6, 101 Grenfell Street, Adelaide.

The agenda will include:

- Minutes of the 2002 AGM;
- Reports from council, treasurer, subscription secretary, the publications committee and the conference committee;
- Motions on notice; and
- General business.

A normal meeting of Council will follow the AGM.

Any financial member wishing to place a motion on notice before the AGM should ensure that the signed motion is lodged with the Hon. Secretary by posting to Australian Rangeland Society, PO Box 4082, Norwood South, SA 5067 by **14th May, 2002.**

If you wish to attend please contact:

John Maconochie
Tel: 08 8204 1837
Email: maconochie.john@saugov.sa.gov.au

Sarah Nicholson
Tel: 041 9815864
Email: nicolson@w130.aone.net.au).

12TH BIENNIAL CONFERENCE 2-5 SEPTEMBER 2002 KALGOORLIE, WESTERN AUSTRALIA

Don't forget the next ARS Conference which will take place in less than six months.

This year's conference theme, "Shifting Camp", has been chosen as a way of acknowledging that the people of Australia's rangelands are in an extraordinary state of transition. We know where we have come from, but there appear to be many possible futures. Drivers for change include the aspirations of the people who live and work on the land (pastoralists, indigenous people and miners) and increasingly the aspirations of people who live in Australia's cities and people who live overseas.

Australia's rangeland will continue to need people to inhabit and manage it. But what will these people do? Economic drivers suggest that there could be substantial changes in the ways that the peoples of the rangeland make their living. How can we achieve the best outcome for rangeland's stakeholders and for the conservation of the resource itself?

The conference will provide a variety of interesting topics of discussion with a number of concurrent sessions operating. The proposed conference program is available online at the ARS website (www.austrangesoc.com.au).

With the call for abstracts having closed on 1st of March, the Organisers are currently very busy finalising the program. Over 60 paper and poster abstracts were received by the closing date. The confirmed program will be outlined in the registration brochure which is set to be distributed at the end of March.

Further details about the conference including the conference program, field tours, social program and accommodation options are also available at the ARS website. Note that this website will be updated as new information becomes available.

Anyone requiring additional information can also contact the Conference Organiser:

Sarah Nicolson,
Intercomm Event Coordination
22 Edmund Ave, Unley SA 5061
Ph: 08 8357 3378 Fax: 08 8357 3389
Email: nicolson@w130.aone.net.au or
sarah_nicolson@urscorp.com

WHERE IS THE NEXT CONFERENCE AFTER KALGOORLIE?

You tell us!

Council is calling for Expressions of Interest in hosting the 13th Australian Rangelands Society Biennial Conference. We are hoping for particular interest from the Northern Territory, as that is the original sequence, although any State can put forward a proposal.

Please discuss this issue with any Officers of the Society, and we will endeavour to assist with your proposal. The convention is for the next conference site to be announced at the preceding conference, so please consider this before the Kalgoorlie Conference in September.

NEW LOGO AND SLOGAN FOR THE SOCIETY

Council are calling for all budding creative people in the Society to have input into the design of a new logo and/or slogan for the society. All we require is a rough draft of a logo and it will be professionally drafted. Please fax or email your creations to Sarah Nicholson (fax: 08 8357 3389 or email nicolson@w130.aone.net.au).

The old slogan, for those who have forgotten, is *Speaking for the rangelands*, and the logo is currently:

AUSTRALIAN RANGELAND SOCIETY

There will be a session at the Kalgoorlie Conference to vote for the new logo and slogan. The prize for the winner of each category is a **one year** membership of the ARS.

STATE BRANCHES - WHAT HAVE YOU BEEN UP TO?

Noelene Duckett, RMN Editor, 7 Belcarra Place, The Woodlands, Texas, USA, 77382.
Email nduckett@ozemail.com.au

I am sure that our readers would be interested in hearing what the state ARS branches have been up to of late. Have you had any interesting guest speakers or any fun social events? If so, please let the rest of know - just email the details to me at the above address.

VIITH INTERNATIONAL RANGELANDS CONGRESS 26 JULY – 1 AUGUST 2003 DURBAN, SOUTH AFRICA

The next international Rangelands Congress is scheduled to be held at the International Convention Centre in Durban, South Africa in mid 2003. Further details about the congress are now available at the congress website: www.ru.ac.za/institutes/rgi/irc2003/IRC2003.htm.

The website includes details about the following:

- Submission of papers;
- Scientific program;
- Conference venue;
- Professional workshops to be held the weekend prior to the congress (26-27 July); and
- Pre- and Post-congress tours (including trips to places such as the Kalahari-Gemsbok Park, Capetown and Victoria Falls).

The website indicates that the scientific program will have five major themes:

- Rangelands as dynamic systems;
- Managing for sustainable use;
- Tenure, livelihoods and sustainable development;
- Enabling frameworks; and
- The new millennium.

The Organising Committee are currently calling for papers for the congress. All Volunteered Papers will take the form of a poster presentation and contributions relevant to any of the themes of the congress are most welcome. Posters will be displayed throughout the congress and at a special poster session. Session conveners will also make every effort to integrate appropriate posters in their sessions. Platform presentations will be by invitation of the session conveners only.

The titles and abstracts of poster and invited platform presentations will be displayed on the conference web page without review, and all Invited and Volunteer presenters will be expected to submit a short paper for publication in the congress proceedings. A title and short abstract should be entered into the on-line registration form on the conference web page to allow session conveners to integrate posters into their sessions. Guidelines for the format of abstracts are given on the website. Note that abstracts for papers are due by the **15 May 2002**.

To be included in future mailings about the conference contact Sue Bumpsteed at delegates@sbconferences.co.za. The first mailing was due to be sent in early March 2002.

NEW MEMBERS

Glenys McKenzie McKinnon
C/- PO Box 1840
DUBBO
NSW 2830

USDA
1701 10'th Ave SW
PO Box 459
MADAN
ND 58554-0459
USA

Rob Pearce
5028 Hwy 6
BISHOP
CA 93514
USA

Sporting Shooters Assoc of Aust Inc
PO 3308
MANUKA
ACT 2603

Mr Philip Baird
PO Box 1034
KUNUNNURA
WA 6743

Miss Marilyn Hunter
PO Box 1166
University of Queensland
Gatton Campus
QLD 4345

Nicole James
PO Box 419
ROXBY DOWNS
SA 5725

Leisa Drury
PO Box 224
CHARLEVILLE
QLD 4470

ERRATUM FOR *RMN* 01/3

Please note there was an error in the article by Amanda Brook and Mike Fleming in the *Range Management Newsletter* 01/3 (December 2001). The caption for Figure 5 (page 5) had the landsystems indicated incorrectly. It should have read *Grazing gradients for (a) sandy landscape type (Pedirka land system) and (b) stony landscape type (Oodnadatta land system).*

INFORMATION SNIPPETS

Community Participation Report

RIRDC (Rural Industries Research and Development Corporation) has recently published a report entitled 'Community participation in rangeland management'. This study was conducted by Dana Kelly from the Rural Extension Centre, University of Queensland at Gatton.

The following is an excerpt from the report:

"Governments are increasingly using participatory approaches for solving rangeland problems. The value of involving local communities is generally appreciated by agencies and their staff, and many landholders appreciate the opportunity for greater involvement with land management programs. Many, however, remain critical of some of the current approaches.

The work reported here surveyed a wide range of landholders and agency staff to determine their attitudes to participation, and to see how future participative programs might be improved. The work also examined how the types of approach could be tailored to the specific situation, the motivations of participants, and what models are effective at different scales.

Interviews were conducted in four Rural Partnership Program regions: two in Queensland, one in New South Wales and one in Western Australia. One of the Queensland regions, the South west strategy, was examined in depth; the other regions were used to validate the findings across the rangelands. Finally, this report proposes guidelines to assist individuals and organisations to choose suitable participatory methods.

This report, a new addition to RIRDC's diverse range of over 700 research publications, forms part of our Resilient Agricultural Systems program, which aims to foster agri-industry systems that have sufficient diversity, flexibility and robustness to be resilient and respond to challenges and opportunities."

The RIRDC report is available online as both an Executive summary and the full report:

- Executive summary (24 kb) can be found at http://www.rirdc.gov.au/reports/Ras/01-118sum.html
- Full report (688 kb) can be found at http://www.rirdc.gov.au/reports/Ras/01-118.pdf.

2002 Eureka Prizes

As indicated in the December 2001 issue of *RMN*, the 2002 Eureka Prizes are bigger and better than ever, with 16 prizes on offer worth almost $160,000.

New prizes to be awarded in 2002 are for research in ethics (sponsored by the Australian Catholic University), engineering journalism (sponsored by the Institution of Engineers, Australia) and health and medical research journalism (sponsored by Pfizer). These join established prizes for environmental and science journalism; environmental education programs; industry commitment to science; critical thinking; promotion of science; secondary school biological and earth sciences; engineering innovation; biodiversity, environmental and scientific research; and science book authorship.

Information on the full range of prizes on offer in 2002, as well as entry forms, is available from the Australian Museum's website at www.amonline.net.au/eureka.

Entries in most prizes close on 17 May 2002, with winners to be announced in August 2002 at a gala award ceremony during National Science Week.

For further information, call (02) 9320 6224 or email rogerm@austmus.gov.au.

El Niño developments

There has been some discussion recently as to whether an El Niño climate event may be developing.

There are a number of websites which can keep you up to date on this issue:

- Bureau of Meteorology website. This site contains lots of information about climate and weather. Specific El Niño information is available at: www.bom.gov.au/climate/enso
- Queensland Department of Natural Resources and Mining/Department of Primary Industries Long Paddock website – www.nrm.qld.gov.au/longpdk/
- Climate Prediction Centre website in the US – www.cpc.ncep.noaa.gov/

The Climate Variability in Agriculture Program (CVAP) website also contains a number of useful links. These take you to sites relevant to national and state climate information, to Australian climate R&D organisations and to international climate websites. The CVAP website can be found at www.cvap.gov.au. Similarly, Agnet contains a directory of popular weather and climate sites. It can be found at www.agnet.com.au/weather.html.

Indigenous ecotourism website

Interested in setting up an indigenous ecotourism venture? Then go to http://staging.qantm.com.au/eco. This website contains tools to be used by indigenous communities interested in setting up tourism enterprises. It features a map of Australia broken up into clickable regions, all of which link to information regarding resources available and recommends steps to be taken for those in that region interested in setting up a tourism enterprise.

Women in Environmental Science Website

CSIRO has recently established a website entitled "Women in Environmental Research". This site features a number of inspirational women scientists and briefly details the environmental research they undertake. The site can be found at:
http://www.csiro.au/index.asp?type=blank&id=WomenInEnvironmentalScience.

Australian Natural Resources Atlas

Don't forget about this great resource! The Australian Natural Resources Atlas is a web-based information system providing natural resource information from across Australia under the broad categories of agriculture, coasts, land, people, rangelands, vegetation and biodiversity and water.

Information is presented at regional, state and Australia-wide scales and is supported by a data library with links to Commonwealth, state and Northern Territory data management systems. Summaries of existing rangeland monitoring systems in Australia can be accessed, as well as reports, maps and data sets developed for Audit projects.

The Atlas is continually updated as new information becomes available and enables users to produce summaries and maps according to specific queries. It can be found at www.nlwra.gov.au/atlas.

Australasian Remote Sensing Conference

The Images to Information Conference will be held from the 2-6 September 2002 in Brisbane. The conference and workshops aim to provide remote sensing solutions for natural resource planners, managers, researchers, industry and agriculturalists.

Further information is available online at www.geosp.uq.edu.au/11arspc or by contacting Karen Joyce, Geographical Science and Planning, University of Queensland on (07)3365 6534.

Savanna Landscapes in Northern Australia - Fire and Heterogeneity Conference

The Tropical Savannas CRC and the Key Centre for Tropical Wildlife Management are holding a conference and linked workshops on the management of fire and its implications for wildlife. It will be held from 8 - 12 July 2002 at the Northern Territory University in Darwin.

The conference is built around two related themes. The first deals directly with fire and management practice. It will summarise much of what is known about fire in savannas, including fire incidence, methods of measuring and describing fire patterns in space and time, and the ecological and resource management implications of those patterns. The second theme will focus more closely on the effects of fire on wildlife habitats, and in particular the role of fire in maintaining or damaging wildlife habitat values and implications of the associated changes in landscape heterogeneity for the dynamics of wildlife populations.

Registration details and further information is available online at http://www.wildlife.ntu.edu.au/activities1.html or from Julian Gorman on Fax (08) 8946 7088.

New Fire Ecology Book

The book 'Savanna Burning' is now available from the Tropical Savannas CRC. This book brings together all aspects of current fire ecology and management research in northern Australia. It costs $30 within Australia, which includes GST and postage and handling.

To order a copy, please send a cheque or money order to Melissa Tang, Tropical Savannas CRC, Northern Territory University, Darwin NT 0909 or you can email your credit card details to melissa.tang@ntu.edu.au. This book will also be available from other outlets in the near future.

The Rangelands Journal – An Update

Volume 23 (2) of *The Rangeland Journal* was recently sent to all subscribers. This issue contained a number of articles which may be of interest to ARS members (see abstracts following). A special issue of the journal focussing on 'vegetation clearing' is scheduled for publication in June this year.

Abstracts of Articles from The Rangeland Journal Vol 23 (2), 2001

Growth rate and effect of sheep browsing on young eucalypts in an anthropogenic *Themeda* grassland - *W.S. Semple and T.B. Koen*

This paper reports the fate of both pre-existing ("lignotuberous") and newly-emerged eucalypt seedlings in an anthropogenic *Themeda australis* grassland on the Central Tablelands of NSW under varying grazing regimes. Compared to reported growth rates on farms elsewhere, the rate of height increase was low for both unbrowsed pre-existing and new seedlings: 16.7 (± 2.5) and 16.6 (± 0.3) cm/a respectively. Heights remained unchanged or declined during the cooler months. Most of the new seedlings were not above sheep grazing height 4.5 years after their presumed time of emergence.

Portions of the seedling population were exposed to a short period of high intensity sheep grazing in spring 1996 and/or autumn 1997. The effect of crash-grazing was more pronounced in spring, when over 90% of available seedlings were browsed, than in autumn when only about half of the available population was browsed. Mortality of new seedlings was higher following grazing in spring than in autumn. The finding that seedlings were not selectively browsed in autumn offers a means of conserving eucalypt regeneration while at the same time deriving some production from pastures. Reasons for different grazing effects in autumn and spring are unknown but could be related to differences between the pastures and/or between eucalypt seedlings on the two occasions.

Turpentine (*Eremophila sturtii*) control by mechanical uprooting - *H.T. Wiedemann and P.J. Kelly*

Turpentine (*Eremophila sturtii* R.Br.) is a tenacious shrub that negatively affects rangeland, and is difficult to control by fire, herbicide or mechanical methods. When above-ground growth is removed, it sprouts vigorously from underground buds on the root system. Uprooting or grubbing is the removal of a shrub and its root crown with a U-shaped blade. Our hypothesis, that depth of uprooting and covering of all exposed roots with soil would influence regrowth, was tested using 100 shrubs divided into five treatments of 20 shrubs each. Each of two depths, 10 and 25 cm, were divided into roots covered and roots exposed. The fifth treatment was uprooting at 25 cm with an extra-wide blade to increase lateral root cutting, and roots were covered. Uprooting depths could not be kept constant and varied from 9 to 33 cm. Plots were evaluated 30-months post-treatment.

Roots covered with soil had significantly greater plant mortality ($P = 0.001$) compared with roots exposed at all depths, when grouped from either 9 to 33 cm, 9 to 19 cm, or 20 to 33 cm. When all depths were grouped, mortality was 82% for plants with roots covered and 5% for plants with exposed roots. Results with the extra-wide blade were not different from uprooting with the narrower blade. These data suggest that the efficacy of commercial uprooting could be improved by covering the roots with soil.

A study to determine rates of grubbing at different plant densities was also included. A 30 kW, farm tractor with a rear-mounted grubbing blade was used. Based on the prediction equation, grubbing rates for 200, 300, and 400 plants/ha would be 1.08, 0.82, and 0.69 ha/h.

Studies of soil seedbanks in native and sown pastures in northern New South Wales - *G. M. Lodge*

Total and germinable soil seedbanks (litter and soil) were studied for a native pasture and three sown pastures (dominated by Phalaris aquatica L. cv. Sirosa) in northern New South Wales from 1993 to 1996. Soil core samples were taken from continuously grazed plots for both pasture types and two oversown treatments in the native pasture and from a spring-autumn rest treatment at the sown pasture sites. At each site above ground herbage mass was also estimated regularly as part of the Temperate Pasture Sustainability Key Program.

For all sites and treatments, the proportion of germinable seeds as a percentage of the total (dormant and germinable) seedbank ranged from 1-26% for the native pasture and 1-39% for the sown pastures. Germinable seed numbers ranged from 280 to 26,110 seeds per m^2, while total seedbank numbers were from 6700 to 178,360 seeds per m^2. Native pasture herbage mass was dominated by native perennial grasses, but seeds of these species were less than 20% of the total seed bank in all treatments in 1994 and 1995. At the sown pasture sites, most of the germinable (51-92%) and total (65-97%) seedbanks were either barnyard grass (*Echinochloa crus-galli* (L.) Beauv, annual ryegrass (*Lolium rigidum* Gaudin), subterranean clover (*Trifolium subterraneum* L.) or wireweed (*Polygonum aviculare* L.). Since seeds of annuals and other forbs generally dominated both the total and germinable seedbanks of these perennial grass-based pastures, these species were likely to increase over time.

Seeds of the sown perennial grass *Phalaris aquatica* L, cv. Sirosa were less than 1% of the total seedbanks in pastures sown in 1990 and less than 3% of those sown in 1979. With above average summer rainfall at the native pasture site in 1996 and prolific growth of redgrass, seeds of this species were 38-63% of the total and 11-29% of the germinable seedbank in May 1996. Except at this site and time, the species composition of the total and germinable seedbanks did not generally reflect the dominance of the above ground herbage mass of these pastures by perennial grasses.

Long-term change in the economic productivity of four major pasture categories on the south-eastern tablelands of New South Wales - *D.T. Vere, R.E. Jones and M.H. Campbell*

The perception of change or decline in the productivity of temperate pastures in south-eastern Australia is an important concern to livestock producers and pasture scientists. Much of this concern relates to reductions in the proportions of desirable species in the composition of pasture systems as a result of increased soil and weed problems. The purpose of this paper is to investigate trends in the long-term economic productivity of four categories of temperate pastures (all introduced pastures, introduced perennial grasses, introduced legumes and all native pastures) on the central and southern tablelands of New South Wales. The results provide evidence of economic productivity decline in the all introduced pastures category in relation to sheep production, but this has been due to productivity decline in the dominant legume component of the introduced pastures. In contrast, there has been strong growth in the economic productivity of the introduced perennial grass pastures. Abnormally high beef cattle numbers in the mid-1970s appear to have created an illusion of high productivity and subsequent decline in all introduced pastures. In contrast, the economic productivity of the native pastures which are the bulk of the region's grazing areas, has fallen substantially.

The economics of temperate pasture systems on the central and southern tablelands of New South Wales - *D.T. Vere, R.E. Jones and M.H. Campbell*

Pastures are the basis of most forms of agricultural production on the New South Wales central and southern tablelands. Pastures occupy the bulk of the region's landmass and pasture-based livestock production annually contributes more than three-quarters of the regional gross value of rural production. Throughout the region, there is substantial variation in pasture composition, ranging from high quality introduced perennial grasses and legumes to pastures comprising mainly low quality native species.

This paper examines the economics of the main categories of temperate pastures over a range of soil fertility-rainfall environments on the south-eastern tablelands areas of New South Wales. Using a linear programming model and discounted development budgets, the results demonstrate the strong influence of the environment on the economics of the individual pasture systems. The highest economic returns in both the short and longer-terms were to the introduced perennial grass pastures in most of the environments. Pastures based on introduced legumes and the high quality native species also generated sound economic returns, although there are recognised problems with the persistence of the legume pastures. Over time, the returns to the better quality native pastures compare favourably with the introduced legumes and are better suited to acidic soils than the perennial grasses. Low quality native species produced relatively poor economic returns in all environments and unfortunately, are the main pasture type in the region's less favourable environments.

Observations on the effects of Rabbit Calicivirus Disease on low and medium density rabbit populations in western New South Wales - *Andy Sharp, Kerry Holmes, Melinda Norton and Adam Marks*

Between winter 1995 and winter 1998, seasonal spotlight counts for rabbits were conducted along three transects in western New South Wales. Rabbit Calicivirus (RCV) arrived at the study site in spring 1996 and had an immediate marked effect on rabbit densities. Prior to the advent of Rabbit Calicivirus Disease (RCD), rabbit abundance followed the expected annual pattern of positive growth during the winter to summer period and negligible or negative growth during the summer to winter period. With the arrival of RCV, rabbit abundance was observed to decline by 47% and 75% within low density populations and by 84% within a medium density population. In the subsequent 21 months, the low density populations returned to levels approximating those prior to the arrival of RCV. In contrast, rabbit abundance within the medium density population remained at consistently lowered levels. These data suggest that RCD will have a minimal effect on semi-arid zone rabbit populations below a density of 0.4/ha and that additional management actions will be required to further reduce rabbit abundances.

Native grasslands on non-arable slopes of the Garrawillie Creek sub-catchment, western Liverpool Plains, New South Wales - *J.M. Bean and R.D.B. Whalley*

NSW Government vegetation legislation over the past five years has highlighted the need for a deeper understanding of native grasslands in NSW. The present study looked at such native grasslands on non-arable slopes in the Garrawillie Creek sub-catchment at the western margin of the Liverpool Plains.

Sixteen sampling sites were selected on two contrasting rock types and aspects. Species composition and frequency scores were determined at each site using eight concentric nested subquadrats.

Cluster analysis revealed seven grassland associations, each designated by a distinctive native grass species. Associated prominent grass species and forbs with 100% fidelity were listed for each grassland association. Within any one association there was a range in condition of the grassland, measured according to the number of perennials + natives relative to the number of annuals + exotics at any individual site.

The seven grassland associations were interpreted as states in a state and transition model, in which rock type, aspect and possibly microtopography were important factors determining the states. With some but not all states, management overrode the underlying factors such that transitions occurred across rock type and aspect boundaries.

The *Sporobulus creber* and *Eriochloa pseudoacrotricha* grasslands were restricted to lighter textured soils on scree slopes of the phonolite lava domes. On the heavy textured soils of the basaltic rocks of the Garrawilla Volcanics, the *Bothriochloa* spp. grassland maintained a characteristic high level of perennials, even where located within a few metres of land cultivated for at least 30 years. In contrast the *Austrostipa aristiglumis* grassland, found at lower altitudes on heavy textured soils, displayed low inertia and stability with natives:exotics and perennials:annuals ratios, at the site sampled, close to 1:1. The *Eriochloa pseudoacrotricha* and *Aristida ramosa* grasslands were limited to NW slopes.

Integrated shrub management in semi-arid woodlands of eastern Australia: effects of chemical defoliants applied after an initial disturbance - *James C. Noble, Anthony C. Grice, Melissa J. Dobbie, Warren J. Müller and Jeff T. Wood*

Previous fire experiments using artificial fuel have shown that annual fires, especially those applied in the autumn, can effectively control coppicing understorey shrubs in semi-arid woodlands. Such frequent fire is impossible to apply under natural conditions given the limited time available for sufficient herbage fuel to accumulate. Preliminary screening studies were therefore undertaken to test the hypothesis that chemical sprays applied at concentrations less than those normally recommended could be used to mimic high-frequency experimental fires.

The effectiveness of 11 chemicals (7 arboricides and 4 dessicants) applied at a range of concentrations was assessed on one site by spot-spraying 5-year-old coppice regeneration of *Eremophila mitchellii* (budda or false sandalwood) and *E. sturtii* (turpentine). Chemical activity was assessed by regularly monitoring leaf effect, i.e. by rating the degree of leaf discolouration, scorching, blackening and ultimately leaf fall, over the ensuing 12 months following treatment. Arsenal® and Roundup CT® induced the highest shrub mortalities across all size classes while mortality rates were consistently higher for *E. mitchellii* than for *E. sturtii*. A second experiment involved 5 chemicals (4 arboricides and 1 dessicant) applied in a similar manner to 7-year-old seedlings of *Cassia nemophila* (syn. *Senna nemophila*) (punty bush). Significant damage to foliage (> 80% leaf effect) of all 3 shrub species was recorded 2 months after treatment with either Roundup CT® or Roundup® (i.e. either 450 or 360 g/L glyphosate respectively), as well as with Arsenal® (250 g/L imazapur + 60 g/L isopropylamine) but only at the highest concentration (i.e. 100% of the 'recommended' rate). In some lower concentration treatments, leaf effect was still increasing 6 months after treatment.

In a second series of screening experiments involving 1- and 2-year-old coppices sprayed in autumn and spring, significant interaction occurred between coppice age and season of spraying when averaged over both *Eremophila* species. At lower concentrations (i.e. 12.5 and 25% of maximum recommended rate), autumn application of Roundup CT® was more effective than spring application, especially once regeneration was 2 years old. Gramoxone® was also most effective at all rates above 12.5% of the maximum when applied in the autumn to two-year-old coppice. However, Garlon® (600 g/L triclopyr) and Tordon 50-D® (50 g/L picloram + 200 g/L 2,4-D) were more effective when applied to 1-year-old coppice in the spring. Overall, the most effective low-concentration treatment was Roundup CT® applied in the autumn to two-year-old coppice. Low-concentration treatment of one-year-old coppice with Roundup CT® and Arsenal® was also consistently more effective when carried out in the autumn (80-90% leaf effect). The probability of shrub mortality was inversely related to coppice biomass with smaller coppices clearly more vulnerable to the added pressure imposed by secondary chemical treatment, independent of application rate.

MEMBERSHIP RATES FOR 2002

Council has decided not to increase subscription rates for 2002. The rates are as follows:

Individual or Family

Full (Journal & Newsletter)		
	Australia	$73
	Overseas (Air Mail)	$96
	Student	$56
	Student Overseas	$73
Part (Newsletter only)		
	Australia	$40
	Overseas (Air Mail)	$51
	Student	$39
	Student Overseas	$30

Institution or Company

Full (Journal & Newsletter)		
	Australia	$107
	Overseas (Air Mail)	$130
Part (Newsletter only)		
	Australia	$56
	Overseas (Air Mail)	$68

Serial Publications

2002 Bibliographic Details and Subscription

1. The Rangeland Journal

Title:	The Rangeland Journal
ISSN:	0313 4555
Volume Number:	23
Frequency:	Two (2) issues per year
Language:	English
Months of Publication:	June, November
Subscriptions:	For calendar year only
Cancellations:	Accepted
Claims:	Must be submitted within 6 months
Index:	No index or title page published

Subscription Rate:

Australia/NZ	A$90 per annum
Overseas (Air Mail)	A$107 per annum

2. Range Management Newsletter

Title:	Range Management Newsletter
ISSN:	0812 4930
Volume Number:	2001
Frequency:	Three (3) issues per year
Language:	English
Months of Publication:	March, July, and November
Subscriptions:	For calendar year only
Cancellations:	Accepted

Claims:	Must be submitted within 6 months
Index:	No index or title page published

Subscription Rate:

Australia/NZ	A$62 per annum
Overseas(Air Mail)	A$73 per annum

3. Joint Subscriptions

The Rangeland Journal and Range Management Newsletter

Joint Subscription Rate:

Australia/NZ	A$130 per annum
Overseas(Air Mail)	A$158 per annum

Note that Membership rates are quoted in AUSTRALIAN currency and must be paid in AUSTRALIAN currency. Visa card, BankCard, and MasterCard are accepted. All rates shown are for AIRMAIL.

AUSTRALIAN RANGELAND SOCIETY
MEMBERSHIP APPLICATION FORM

Please complete and return to the Subscription Secretary, Rob Richards, PO Box 235, Condobolin 2877 NSW

I, [name] ....

of [address] ....

....

Postcode.................. Email address ....

apply for membership of the Australian Rangeland Society and agree to be bound by the regulations of the Society as stated in the Articles of Association and Memorandum.

Enclosed is a cheque for $AU......................... for full/part* membership for an individual/student/institution* for the calendar year 2002

Charge my Mastercard VISA Bankcard AU$....................for full/part* membership for an individual/student/institution* for the calendar year 2002

Card No.:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Expiry Date: ....

Signature:............................... Date: .... Cardholders Name:............................

*delete as appropriate

If you were introduced to the Society by an existing member please include their name here ....

Please list details of your institution & student number if you are applying for student rates ....

Membership Rates:

	Australia	Overseas Airmail
Individual or Family -		
Full (Journal + Newsletter)/Student	$73.00/$56.00	$96.00/$73.00
Part (Newsletter only)/Student	$40.00/$30.00	$51.00/$39.00
Institution or Company -		
Full (Journal + Newsletter)	$107.00	$130.00
Part (Newsletter only)	$56.00	$68.00

Please Note –

1. Membership is for the calendar year 1 January to 31 December. All rates are quoted in AUSTRALIAN currency **and must be paid in AUSTRALIAN currency.**
2. **Year 2002 membership rates include Airmail for all overseas subscribers.**

For Office Use Only:

Membership Number ....

Date Entered in Member Register ....

Date Ratified by Council ....