GRASSROOTS

Editor **JULIUS TJELELE**

Dear Readers

45th Annual Congress to be held in Kimberly is fast approaching and thus far a lot of delegates have registered to attend this Congress compared to previous year this time. One of the most important things about attending the GSSA congress other than presenting scientific papers is networking. Horseshoe Motel, Airport Hotel and other accommodations are close to each other, and this will facilitate networking. So, it is not too late to make necessary arrangements to attend this year‘s exciting GSSA Congress.

To some of you might have forgotten or does not know; this year is the 20th Anniversary of the establishment of the Bulletin of the Grassland Society of Southern Africa. The first issue was published in December 1990. As GSSA family we are going to celebrate this in style come November Grassroots issue.

Julius

GSSA Council

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GRASSROOTS

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News

Features

Regulars

The Grassland Society of Southern Africa is dedicated to the advancement of the science and practice of range ecology and pasture management.

We welcome any contributions to the Grassroots, in the form of news, informative articles, reports, short research notes, scientific papers and letters to the Editor.

Email jtjelele@arc.agric.za or admin@grassland.org.za or fax +27 (0)86 622 75 76

On the cover: Farmers day at ARC, Roodeplaat Farm, Photo: Frits Oudtshoorn

National Sustainable Livestock Task Team: A GreenChoice-Grassland Initiative

Background

The National Sustainable Livestock Task Team met for the first time in March 2009. The purpose of the workshop was to: a) provide stakeholders with updates on activities in livestock industries as well as conservation advocacy agencies, b) consider the form of National Sustainable Livestock Working Group in the future.

Updates on activities were provided by Grasslands, GeenChoice, Red Meat Organization (RPO), Landmark Foundation, National Wool Growers Association (NWGA), Mohair South Africa, Cheetah Outreach and Biodiversity and Red Meat Initiative (BRI).

Key updates

• The RPO and NWGA have developed code of practise and would like GreenChoice input.

• MWGA is developing a strategic framework.

• Mohair SA has produced the Sustainable Mohair Production Guidelines: pre-farm gate, which was aligned with the reference for well managed farms and produced in consultation with producers.

• Grassland programme is working on a Biodiversity Red Meat Certification initiative and Grassland guidelines to inform appropriate agricultural management practice, and is implementing case studies.

• Landmark foundation has certified its first farmer for their Fair GameTM brand.

• Cheetah Outreach continues to be involved in the Anatolian Shepherd Dog Programme, has started a breeding programme and is the first to use dogs with cattle.

• The Biodiversity and Red Meat Initiative in Kamiesberg Uplands, Namakwa District has begun with stewardship agreements between Conservation International and community/private farmers with small stock. Guidelines are being developed in collaboration with GreenChoice.

• The first official version of the GreenChoice 'Reference for well managed Farms" will be distributed to stakeholders.

Key outcomes

• The stakeholders agreed to meet to foster communication, knowledge sharing around business cases for sustainable livestock farming, and identification of research gaps.

• The group will reconvene as "The National Livestock and Wildlife Task Team' where livestock includes small stock, large stock, game, all extensive and intensive livestock farming.

• Meeting will occur ad hoc when progress is made or at least once a year.

• Initiatives will continue to be driven by industry/ conservation but greater government presence must be sought for future meetings.

• Need to align activities with Strategic Plan for South African Agriculture.

• A request that all members of the GreenChoice Alliance review industry guidelines based on the Reference for well-managed farms was made by Landmark Foundation.

GreenChoice Newsletter

South African Environmental Observation Network (SAEON) Ndlovu - 'Proudly South African' in the Swiss Alps

DR D THOMPSON,
Biodiversity scientist and,

DR TONY SWEMMER,
Manager, SAEON Ndlovu Node

Global change is already affecting the mountainous regions of the world, with clear evidence of altered weather patterns and the upslope shift of alpine species.

Yet in South Africa, little long-term environmental monitoring of our mountains is taking place, and this is something which is desperately needed if we are to detect and respond to the looming impacts of a changed climate. This is in contrast to many northern hemisphere first-world countries, which have long histories of detailed environmental monitoring. Of these, Switzerland stands out as the global leader.

Ecological monitoring in Swiss Alps

In November last year Tony Swemmer and Dave Thompson of the SAEON Ndlovu Node visited Switzerland to learn about the ecological monitoring being conducted in the Swiss Alps. The trip was made possible by funding for a Swiss-South African Joint Scientific Conference entitled "Towards Fine Resolution Hydro-Ecological Observatories in South African Mountains" and was initiated specifically to promote international collaboration, knowledge transfer and the establishment of a network of permanent environmental observatories in southern African mountains.

The programme covered observing systems related to climate, the atmosphere, hydrology and biodiversity, and took place at the Swiss National Park (Zernez), the Swiss Federal Institute for Forest, Snow and Landscape Research (Davos), the Federal Office for the Environment (Bern) and the University of Lausanne.

Together with the other South African participants (from the Universities of Pretoria, Witwatersrand, KwaZulu-Natal and Stellenbosch, Ezemvelo KZN Wildlife and private nature reserves), Tony and Dave were absorbed in discussions and institute / monitoring site visits led by colleagues from the Swiss National Park, MeteoSwiss (the Swiss weather service), the Swiss GCOS Programme, the Swiss Phenology Network, the WSL (the Swiss Federal Institute for Forest, Snow and Landscape Research), SwissEx (a group developing sensor networks within the WSL), the Hydrology Division of the Federal Office for the Environment, the Swiss Biodiversity Monitoring Program, GMBA (Global Mountain Biodiversity Assessment), MIREN (Mountain Invasion Research Network) and GLORIA (Global Observation Research Initiative in Alpine Environments).

In return, the South African contingent shared information and challenges relating to current hydro-ecological monitoring efforts taking place in South African mountains.

SAEON Newsletter

Pretoria Computerised Information System (PRECIS) content available on the Web

Are you aware of PRECIS content that are now available, free-of-charge, on the Web?

The Plants of Southern Africa (POSA) provides information about all SA plants, their distribution and current names and links to other resources such as plantzafrica. It also provides access to images of many plants which can be downloaded at http://posa.sanbi.org/searchspp.php

SANBI's Integrated Biodiversity Information System (SIBIS) which provides threatened species information, distribution maps, area checklists and general species details http://sibis.sanbi.org/

Please make use of these facilities to download, free-of-charge, information that, in the past, you would have requested from the PRECIS Information Officer. Requests for complex data sets may still be directed to the PRECIS Information Officer (precis@sanbi.org.za). Any queries / comments about the data on the POSA or SIBIS websites should also be directed to the PRECIS Information Officer.

Any queries or comments about the structure or functionality of the websites should be directed to Mr. Reuben Roberts (r.roberts@sanbi.org.za).

SANBI

Grassland Society Southern Africa/Grootfontein Agricultural Development Institute Research Skills Workshop

The Grassland Society of Southern Africa, in collaboration with Grootfontein Agricultural Development Institute, are proud to host a Research Skills Workshop on 21 and 22 September 2010. During this two-day event, researchers, scientists, academics, lecturers, and practitioners will make presentations on issues related to research. Presentation cover a wide range of topics, including the philosophy of science, the scientific method, writing skills, the working environment, and how to make successful poster and platform presentations.

Speakers include:
Justin du Toit (Convenor, Specialist Scientist, GADI)

Dr Luthando Dziba (Senior Manager, Rangelands and Nutrition, ARC)

Dr Terry Everson (Senior Lecturer, University of KwaZulu-Natal)

Steve Germishuizen (Consultant, Forestry Coordinator of Grasslands Programme)

Lisa Hebbelmann (MSc Student, University of KwaZulu-Natal)

Dr Terry Olckers (Senior Lecturer, University of KwaZulu-Natal)

Dr Tony Palmer (Specialist Researcher, Ecology and Biomes, ARC)

Dr Johan van Rooyen (State Veterinarian, GADI)

Dr Adrian Shrader (Senior Lecturer, University of KwaZulu-Natal)

Prof David Spurrett (Professor of Philosophy, University of KwaZulu-Natal)

Dr Susanne Vetter (Lecturer, Rhodes University)

Prof Dave Ward (Professor of Botany, University of KwaZulu-Natal)

Who should attend?
The workshop will be of benefit to scientists, researchers, teachers, managers, technicians and students, especially those involved in agriculture, rangeland science, biology, ecology, and applied sciences.

Venue
The workshop will be held at the Grootfontein Agricultural Development Institute in Middelburg in the Eastern Cape. Accommodation is available in the town and on guest farms in the vicinity. There will be a tour of Grootfontein after the workshop for those who wish to attend, which will highlight current research initiatives, and reflect on its interesting history as a British military camp and training centre from 1903-1910 (see http://gadi.agric.za/history.htm).

Further information
For more information on the workshop, including rates, please visit http://www.grassland.org.za/functions or email Freyni du Toit, the administrator of the GSSA, at admin@grassland.org.za.

SAEON plays vital role in monitoring South Africa's premier water engine

PROF T O'CONNOR,
SAEON Observation Science Specialist

The grassland biome, which covers 29% of South Africa's surface area, has provided the fabric upon which the industrial heartland of the country has developed.

The grassland biome is the mainstay of crop and livestock agriculture in the country, supports most of the country's rural population, functions as the country's most important water-manufacturing engine, and contains globally significant biodiversity.

Yet 30 % of the biome has already been irretrievably transformed. There is a pressing need to conserve what remains of this biome and to ensure continued delivery of its essential ecosystem services.

A century of investigation
Why is this biome grassland and not some other form of vegetation such as savanna, forest, karoo, or fynbos?

This question remains at the cutting edge of vegetation theory despite close on a century of comment and investigation. Fire is an integral component of this discussion. Many argue that the grassland biome is simply a consequence of frequent fires precluding woody vegetation. In theory, this is easily tested – preclude fire and measure the consequent vegetation changes.There are, however, two simple stumbling blocks. Vegetation change may be slow, thus fire would have to be precluded for an extended period, which is not easy in a fire-prone environment and requires a dedicated effort.

This country is fortunate in having had a handful of visionary ecologists before our time who initiated such experiments 50 or more years ago. It is further fortunate that research was part of a government department's responsibilities, such that adequate resources were available for maintaining these experiments. Two such efforts are located in the Drakensberg region of KwaZulu-Natal at Cathedral Peak and at nThabamhlope. These efforts have experienced different histories since their establishment that offer valuable insights about the relation between fire and vegetation dynamics.

A new research programme has been initiated through a research partnership comprising SAEON, Ezemvelo KZN Wildlife and the University of KwaZulu-Natal. The project is funded by the National Research Foundation through a grant to Prof Tim O'Connor.

Cathedral Peak and nThabamhlope
The SAEON-led study focuses on Cathedral Peak and nThabamhlope. Cathedral Peak was home to one of the outstanding achievements of South African science – the study of long-term water yield from grassland in response to fire management and afforestation.

nThabamhlope used to be a research farm of the KwaZulu-Natal Department of Agriculture until the land was returned to the local community in the 1990s. John Scott and Oliver West established two plots in 1939 that were completely protected from fire and grazing, and described the vegetation at that time. These plots were re-measured by Bobby Westfall, Colin and Terry Everson in 1979, after forty years of protection. At this time both had established closed canopies of woody plants.

Much ground has already been covered in the programme as vegetation change has been studied in detail. Ed Granger completed his PhD on the first twenty years of vegetation succession. Keryn Adcock undertook her MSc on the next twenty odd years of change. These efforts not only documented the rate and pattern of change, but offered well-supported hypotheses about vegetation succession in this environment.

The current MSc research effort continues this tradition to provide a 60-year chronicle of vegetation change. An accidental fire in 2008 has provided a further opportunity to assess directly the impact of fire on this vegetation succession. Hypotheses of the original workers are being refined.

Forces of change

A start has been made with the study of long-term patterns in the fire regime at a landscape scale as fire is a main ecosystem driver. A robust foundation exists for understanding vegetation changes. Fire has been precluded for up to 60 years at Cathedral Peak, Giants Castle and nThabamhlope, thereby offering an unparalleled opportunity to examine succession from grassland to woodland/forest.

Aerial photographs are another invaluable source of evidence of the ingress of woody elements into grassland. They offer a 70 -year history that can be extended to 110 years using photographs from the Boer War – the wooded thickets on the flanks of Spioenkop were absent then. Study of bush encroachment on outlying hills in relation to management and topographic influences on fire may presage what lies ahead for the Drakensberg.

Herbaceous vegetation has also received close attention in the past. Additional long-term fire and grazing experiments, plus numerous fence-line contrasts between the protected area and areas accessed by livestock, will allow a comprehensive assessment of forces of change of this vegetation component. Altitudinal transects will be consolidated from existing plots of herbaceous vegetation in order to examine altitudinal shifts in vegetation, especially the expected expansion of C3 grasses and other plants at lower altitude.

Changes in fire regime and vegetation would affect the quality and quantity of resources on which large mammalian herbivores subsist. There is concern about oribi, klipspringer may already have been lost, red hartebeest have been unsuccessfully reintroduced, eland and bushbuck thrive, while the well-being of grey rhebuck and mountain reedbuck is unknown. Research continues on flagship species such as vultures, while a recent broad assessment of biodiversity might serve as a basis for examining security of biodiversity in this World Heritage Site and its surrounds.

The above-described efforts are simply the first steps in addressing a complex system that capitalises on past research and monitoring. In the near future it is hoped that greater attention can be paid to the influence of land use on ecosystem services.

Effect of different drivers of change

The aim of the study is not simply to show that change is occurring, but to understand the effect of different drivers of change on ecosystem structure and functioning. This, to some extent, is an important contribution of this work as most global change studies focus mainly on establishing that change is taking place. Understanding the actual contribution of individual factors to change is important because it would lead to a targeted approach in terms of mitigation.

Another important impact of the study would be its use of ecosystem as a unit of analysis. Although ecosystems are complex and therefore predicting their response under 'natural' conditions is challenging enough without the added complexity of global change impacts, there is a pressing need to aggregate understanding of responses of components or processes into an understanding of ecosystem-level response. Failure to include the complexity of ecosystem structure and functioning increases the risk of erroneous prediction of global change impacts. The research will also yield an understanding of biome shifts (contraction), biodiversity and the threat of alien invasive plants, biogeochemical cycling and productivity, including carbon flux, hydrological functioning and sediments, as well as fire regimes.

The research is also expected to contribute immensely to the understanding of hydrological functioning of catchments and the associated ecosystems; and model climate change, land use, fire, invasive plants, river management, and nutrient loading impact on them.

SAEON Newsletter

Funding Opportunities

Wildlife Conservation Society: Research Fellowship Program

The Research Fellowship Program (RFP) is administered by WCS-Global Conservation's Training & Capacity Building Program and jointly funded by the Conservation Leadership Programme (CLP). The RFP is a small grants program designed to build capacity for the next generation of conservationists through supporting individual field research projects that have a clear application to the conservation of threatened wildlife and wildlife habitat. We seek projects that are based on sound and innovative conservation science and that encourage practices in conservation that can contribute to sustainable development. Most of the grantees are professional conservationists from the country of research and/or post-graduates pursuing a higher degree.

One of the priorities of the RFP has been to help train applied conservation scientists from developing countries. Over 41% of the total funded proposals have come from national conservationists (conservationists who are citizens of the country where they are conducting their research). 48% of grants to work in Latin America have been to nationals, 43% of grants to work in Asia have been to nationals, and 32% of grants to work in Africa have been to nationals. Collectively, these young professionals will help to apply field-tested conservation science to the challenges facing the conservation community.

Applications

Location The RFP supports marine or terrestrial field research in Africa, Asia, and Latin America regardless of the nationality of the applicant. In addition, the RFP accepts applications from Native Americans (US) and First Nation Peoples (Canada) who intend to conduct work on native lands on issues of direct relevance to wildlife.

While all applications to work in Asian, African, and Latin American countries are considered, CLP funding is restricted to nationals from the following countries: Algeria, Angola, Argentina, Azerbaijan, Bolivia, Brazil, China, Colombia, Egypt, Georgia, India, Indonesia, Libya, Malaysia, Mexico, Pakistan, Russia, Trinidad & Tobago, Turkey and Venezuela.

The RFP does not support research in North America (except as mentioned above), Australia, New Zealand, Europe or their territories, or Japan.

Grantees

The RFP will not limit any eligible individual from applying, however, most of our grantees are:

- Professional conservationists from the country of research, and/or
- Post-graduates pursuing a higher degree Grants
- Grants are for up to $25,000 and the average grants is $10,500.

Timeline

The RFP supports projects for only one year, so preference is given to discrete, short-term projects. Projects extending beyond one year must highlight achievable goals at the end of the year for which the funding is requested. Proposals are submitted in a standard format for two annual cycles with deadlines on March 15 and September 15. Final decisions and awards are usually announced at the end of June (for the March 15 deadline) and December (for the September 15 deadline) with funding becoming available in July and January.

Review and Evaluation

Proposals are evaluated on a competitive basis by outside technical reviewers and WCS staff. Projects are evaluated on three major criteria:

- Applicant's potential as conservation professional: the capacity building value of the proposed project.
- Relevance to wildlife conservation: a clear application of the research results to an important conservation question
- Scientific merit and value: in particular a clearly expressed research question with appropriate methodology and analysis.

For more detailed information about the application process visit, www.wcs.org/international/tcbp/rfp/rfpapplication

Swedish Research links programme

International Collaborative Research Grants Sweden, Asia, MENA and southern Africa

The Swedish Research Links Programme seeks to foster research ties between researchers in Sweden, on the one hand, and researchers in Asia, the Middle East and North Africa region (MENA) and southern Africa on the other. The key condition for the Swedish Research Links Programme is that researchers from the countries involved must submit joint applications on projects of mutual interest. Contact person: Raven Jimmy National Research Foundation Tel: 012 481 4069.

AU-TWAS Young Scientists' National Award

The AU-TWAS Young Scientist National Award which is open to both male and female young researchers is designed to recognize the scientific achievements of young researchers working and living in Africa and to encourage them to continue to strive for excellence in their scientific careers.

In each African country, the AU-TWAS award will be given annually in the following 2 fields of science:

- Life and Earth Sciences;
- Basic Sciences, Technology and Innovation.

For each award, AU and TWAS shall make available a yearly amount of up to US$5,000 as prize money. In addition to the cash award, the winners will also receive a certificate.

This new initiative, to be implemented from 2010, has been developed from the existing TWAS award for your scientists from developed countries. In African countries, the AU-TWAS Young Scientists National Award will replace any previous agreement of collaboration signed with TWAS within the framework of the prizes to young scientists from developing countries.

The deadline is 30 June 2010.

For more information contact Philistas Masinga at
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Cell No: +27 72 185 8681
E mail: philistas@assaf.org.za

Upcoming events

South African National Seed Organization: 21st Annual Congress
Date: 05-06 May 2010
Venue: Glenburn Lodge Country Estate, Muldersdrift, Gauteng
Contact: Melody Spicer
Tel: 012 349 1438

International Seed Federation World Seed Congress 2010
Date: 31 May - 02 June 2010
Venue: Calgary, Alberta, Canada
Tel: +41 22 365 4420
email: register@worldseed.org

Green Business Africa Summit and Expo 2010
Sustainability in the business environment as well as green corporate social responsibility
Date: 02-04 June 2010
Venue: Nairobi, Kenya
Contact: Sam Ooko
Tel: +254 20 248 7420
email: sam@solargrenmedia.com

Beef Production
Date: 01-03 June 2010
Venue: Agricultural Research Council (Irene), Centurion
Cost: R1600.00
Contact: Annetjie Loubser
Tel: 012 672 9153;
email: aloubser@arc.agric.za

4th Grazing Livestock Nutrition Conference
Improving Ruminant Usage of Forages in Sustainable Production Systems
Date: 09-10 July 2010
Venue: Estes Park, Colorado, USA
Contact: Dr. Richard Waterman
email: Richard.waterman@ars.usda.gov

5th International Wildland Fire Conference - South Africa
Date: 09-13 May 2011
Venue: South Africa
Tel: +27 (21) 797 5787
email: info@wildfire2011.org

Council members

Council Members, with the exception of the Scientific and Publication Editors, are elected at the Annual General Meeting after being nominated by fellow Members of the Society. The Vice President is elected each year, while all other positions are filled every two years. The Scientific Editor and Publication Editor are positions appointed by the retiring Council at the last meeting of their term.

If you would like to nominate a fellow Society Member to stand on Council, please download, download the nomination form from www.gssa.za/council-members and fax it to +27 (0)86 622 7576.

Positions that need to be nominated for the 2010/2011 Council are:

- Vice President
- Honorary Secretary
- Honorary Treasurer
- Additional Member (Assistant Publications Editor)
- Additional Member (Website Editor)
- Additional Member (Pastures)

All retiring Councillors shall be eligible for re-election, except the retiring President, who shall not be eligible for re-election for the ensuing term, but shall remain on the Council as Immediate Past President.

New and resigned members

New members
Benjiman Breedlove, BBreedlove (Pty) Ltd

David Lotter, Themeda Game Farm Services, Managing Director
Graham von Maltitz, CSIR, Senior Researcher

Hennie de Beer, Agricultural Research Council, Research Technician

Lerato Letsoalo, Limpopo Department of Agriculture, Animal Scientist

Lindiwe Mbele, Agricultural Research Council, Research Technician

Lucas Manaka, Agricultural Research Council, Research Technician

Mike Schellenberg, Agriculture and Agri-Food Canada, Research Scientist: Plant & Range Ecology

Rick Dillon, Self Employed, land use planning and rural development

Thabisisani Ndhlovu, University of Stellenbosch, MSc Student

Thuys Botha

Yolandi Bezuidenhout, Highveld Steel & Vanadium Corporation, Environmental Manager

Resigned members
Albert Smith
Colin Pringle
Hennie Gerber
P Yiannakis

Farmers day at ARC, Roodeplaat Farm, Photo: Frits Oudtshoorn

GRASSROOTS

Newsletter of the GRASSLAND SOCIETY of SOUTHERN AFRICA

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Feature

Longevity of grass seeds in a semi-arid grassland

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Introduction

The soil seed bank plays an important role in the composition of different plant communities and thus in their conservation (Bekker *et al.* 1997). In arid and semi-arid grasslands, seed rain events are primarily driven by episodic events and secondarily by continuous trigger events such as rainfall and fire (Page and Harrington 2009). The composition of the seed bank depends on the production and composition of the present and previous communities as well as on the longevity of the seeds of each species under local conditions (Bekker *et al.* 1997; Thompson and Grime 1997).

The understanding of the function and dynamics of seed banks has become a great challenge to ecologists working in plant communities, as this understanding is necessary to determine the role of this community in ecosystem functioning and to improve the integrated management of ecosystems (Kinloch and Friedel 2005; Snyman 2009). A complete set of topics on seed banks such as the effects of environmental factors on seed bank dynamics (Baskin and Baskin 1989; Page and Harrington 2009), the spatial distribution of seeds in soil (Shaukat and Siddiqui 2004), seed persistence in soil (Luzuriaga *et al.* 2005) and the resemblance between seed species composition and the aboveground vegetation (Page and Harrington 2009) have been described. Unfortunately, there are only a few studies about the regenerative potential of seed banks (Luzuriaga *et al.* 2005), the longevity of the seeds of each species under specific climatic conditions and the quantification of seed rain in arid and semi-arid areas. This study aimed to evaluate the recruitment of grass species from the seed bank after different types of disturbance in a semi-arid grassland. The longevity of the seeds of each species under local conditions was also quantified over five seasons (2002/03 to 2006/07).

Materials and methods

The study was conducted at Bloemfontein (28° 50'S, 26° 15'E, altitude 1 350 m), situated in the semi-arid, summer rainfall region (mean annual rainfall 560 mm) of South Africa. Mean maximum monthly temperatures range from 17° C in July to 33° C in January, with a mean of 119 frost days per annum.

Grassland in good ecological condition, typical of the Bloemfontein Dry Grassland (Mucina and Rutherford 2006) in the Grassland Biome (Bredenkamp and Van Rooyen 1996) was selected for this study. The botanical composition and basal cover of the grassland in good condition was typical of that on commercial farms in the area and described in detail by Snyman (2000). The soil is a fine sandy loam of the Bloemdal form (Roodeplaat family – 3 200; Soil Classification Working Group 1991). Clay content increases with soil depth from 10% in the A-horizon (0-300 mm), to 24% in the B2-horizon (300-600 mm) and 42% in the B2-horizon (500-1 200 mm).

The research was conducted on 6 plots of 10 m x 10 m each, with a buffer zone of 5 m around each plot. The clipping treatment were clipping with and without seed removal- seed production or seed rain. The seed culms were often removed by cutting, over the growing season, as soon as the growing points began lengthening so that the seeds of the grasses never ripened. Therefore, no seed production or seed rain took place. This treatment was applied to determine the longevity of seeds in this semi-arid climate. In the control treatment, the grasses were allowed to seed and the seed to ripen and fall on the ground as seed rain. The treatments were allocated randomly to the plots with three replications for each treatment.

This research was conducted over five growing seasons (2002/03 to 2006/07). To determine the botanical composition of the field before applying the treatments, a bridge-point apparatus was used. Five hundred points (nearest plant) were recorded per plot. When the species were classified, the ecological status (Decreaser and Increaser species), as defined by Foran et al. (1978), was taken into consideration. The classification of dry *Themeda-Cymbopogon* grassland into different ecological groups as described by Fourie and Visagie (1985) was used.

A soil seed bank is defined as a collection of seeds, at or beneath the soil surface, which are capable of germination. Soil samples were collected randomly in eight blocks (0.5 x 0.5 m each) in every treatment to a depth of 50 mm at the end of every third month. Only the soil between the tufts was sampled up to the base of every tuft. Samples were collected into separate paper bags for immediate transport to the greenhouse for processing within 10 min of collection. In the greenhouse, soil samples were spread evenly in plastic containers (0.5 x 0.5 m) containing a 100-mm deep layer of Hygiotech growth medium (Canadian peat, polystyrene vermiculite and mono-ammonium phosphate). To measure the extent of contamination, eight additional plastic containers filled with autoclave-sterilised soil (90^{o} C for 1 h, repeated three times over a week) were included with each set of soil samples. Seedling plastic containers were placed at random in the greenhouse. Containers were hand-watered daily, after which the seedlings were identified and counted daily over a two-month period. All identifiable seedlings were removed. Seedlings that could not be identified after two months were potted individually and grown until identification could be made. The soil medium ensured that the plants that germinated could reach a stage where they could be identified before dying down. Respective day and night temperatures of 25–30^{o} C and 15–18^{o} C were maintained in the greenhouse to simulate grassland conditions.

The seed bank was investigated at the beginning of October (before the new seed set), at the beginning of January (after the first seed production event) and at the beginning of April (after the second seed production event). The phenological pattern of the vegetation in the study area is characterised by these two seed setting periods every season under normal rainfall conditions. The October soil sampling, after seasonal germination had occurred and before the first spring rainfall, therefore represented the size of the persistent or potentially germinable seed bank.

Seedlings that germinated in the field in response to sufficient rainfall over the specific periods were counted over the growing seasons. This was accomplished by randomly distributing ten quadrates (0.5 x 0.5 m each) per treatment. Unfortunately, the survival of the identified seedlings was not monitored: only their emergence.

Within-year and between-year data were analysed separately. For seedling density, sub-sampling was employed where data were averaged across quadrats within plots and then analysed among treatments and sample periods. Tukey's procedure for comparison of means was applied. The Number Cruncher Statistical System (2000) software package was mainly used. Similarity between seed bank and field vegetation was tested using Sorensen's similarity index (Greig-Smith 1983).

Results

Botanical composition in field

The field's botanical composition was dominated by *Themeda triandra,* which constituted 81% of the species composition. Only 4% of the species was Increaser type II(c). This botanical composition clearly showed that the field was in a good condition at the onset of the study. Interestingly, no forbs occurred in the field. A full analysis of the species frequency can be found in Snyman (2000). Botanical composition did not vary much over the five seasons.

Seed bank germination in the greenhouse

Four days after inception of the germination study in the greenhouse, the first seedlings emerged, mostly *Eragrostis* seedlings. After seven days, most seedlings of the other grass species also emerged. Within three weeks no further seedlings emerged, although observations were still carried out for a further six weeks to identify all seedlings.

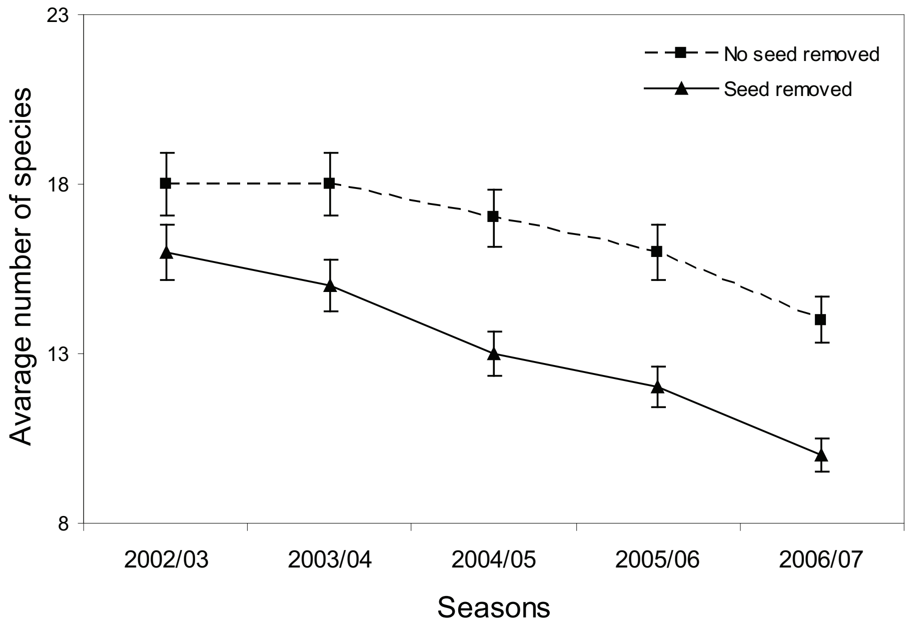
On average throughout the study period, the seedling densities of the species *Digitaria eriantha, Eragrostis chloromelas, E. superba, E. lehmanniana* and *Sporobolus fimbriatus* were similar in the seed bank, regardless of treatment applied or time of year the seed was gathered. In contrast, the seedlings of *Cymbopogon pospischilii, Panicum stapfianum* and *Triraphis andropogonoides* emerged in the seed bank only with the spring (October) soil collection. The seed of *Eragrostis plana* only germinated when the soil was collected in January, while *Agrostis lachnantha, E. obtusa* and *Elionurus muticus* only germinated with the April soil collections, over the trial period. On average over the growing seasons and regardless of treatment applied, *Themeda triandra* only germinated in the spring and autumn and not at all in the middle of the season (January). The rest of the grass species did not exhibit a clear germination pattern over the season and were also influenced to a greater or lesser extent by the different treatments. The seedling emergence of forbs and weeds was best in the autumn and poor in October.

After only four years of removing seed, no further seedling emergence of the Decreaser species (*Digitaria eriantha, Helictotrichon turgudulum, Panicum stapfianum, Pentaschistis setifolium, Sporobolus fimbriatus* and *Themeda triandra*) occurred in the seed bank and field. This cessation in seedling emergence was a marked ($p < 0.01$) occurrence as the previous season (2004/05) was characterised by seedling emergence in the seed bank in all the Decreaser species. This tendency only occurred among the Decreaser species, while the Increaser species showed almost the same germination after four years of seed removal, compared with the treatment where no seed was removed. Among the Increaser species, especially *Cymbopogon pospischilii, Eragrostis lehmanniana, E. plana* and *Heteropogon contortus* had almost no seedling emergence after four years of seed removal. Notably, the germination of *E. chloromelas* was not at all influenced by seed removal after four years and this still had a high seed presence in the seed bank. This same trend was repeated the next year. The emergence of the forb seedlings were also not significantly influenced after four years of grass seed removal. *Aristida congesta, Tragus koelerioides, Elionurus muticus* and *Bromus catharticus* are the only species emerging in the seed bank after four years of seed removal, but were not found where the seed was not removed.

The species *Digitaria argyrograpta, Setaria sphacelata var. sphacelata, Lycium tenue* and *Walafrida saxatilis* (4/27 species) only occurred in the field and never in the soil seed bank over the five years. Those species only occurring in the seed bank over the 5 years, but not in the field, included *Helictotrichon turgidulum, Panicum stapfianum, Pentaschistis setifolium, E. lehmanniana, E. superba, E. plana, Agrostis lachnantha, E. gummiflua, Cynodon dactylon, C. hirsutus, Elionurus muticus, Bromus catharticus* and *Eleusine coracana* (13/27 species). The forb species were not accounted for in the above species richness.

The species richness significantly ($P < 0.01$) declined for both seed removal and absence of seed removal for the last four years of applying the treatments (Figure 1). Notably, where the seed was removed over the five years, the species richness was significantly ($P < 0.01$) lower for all the years than in plots where it was not removed.

Figure 1: Species richness (mean number of species) for the clipping treatment for the 2002/03 to 2006/07 growing seasons. Error bars are the standard error of means (n = 3), where they are significantly different (P <0 .01). LSD0.01 = 1.3.



Vegetation similarity between seed bank and aboveground (field)

In the perennial grassland (field) before disturbance, relatively low similarity was detected between species composition in the vegetation and in the seed bank for both treatments (Table 1). Considering the abundance of each species, vegetation was mainly dominated by perennial grasses whereas the seed bank was dominated by early succession grasses and forbs. The similarity index decreased from the first to the fifth season where seed was removed from an average of 64.28 to 35.71.

Table 1: Similarity in grass flora between seed bank and aboveground vegetation (field) by calculation of the Sorensen's similarity index for the 2005/06 season.

No seed removal	Seed removal
60.24	35.71

Seed bank size

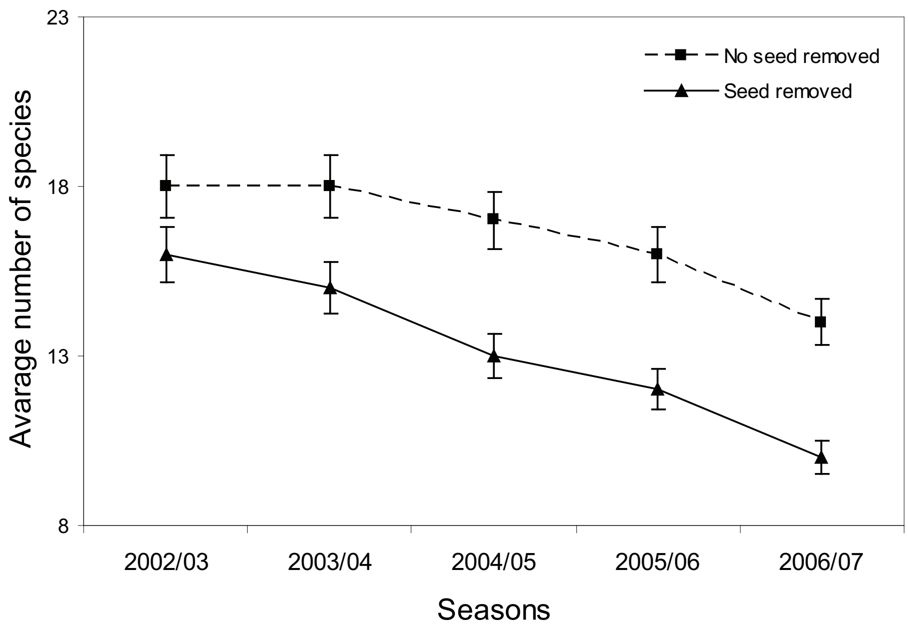
As expected, where the seed was removed a significant ($P < 0.01$) decrease in seedling density occurred in the seed bank, compared with where the grasses could produce seed undisturbed for all five seasons (Table 2). In general, the seedling density of the January soil collection was the highest, with that of October the lowest. The impact of seed removal was severe ($P \leq 0.01$) on the seedling density for all three months.

Table 2: Mean seedling density (mean number of live seedlings m-2) obtained by the seedling emergence method from soil samples of grassland for different treatments. Soil samples were taken in October, January and April for the 2002/03 to 2006/07 growing seasons, and were germinated in the greenhouse. Data are means and standard errors. Different letters indicate significant (P <0 .01) differences among clippings.

October		January		April	
No seed removal	Seed removal	No seed removal	Seed removal	No seed removal	Seed removal
132.8a ± 10.16	86.2b ± 4.14	242.2a ± 39.12	186.8b ± 21.20	128.8a ± 20.14	79.4b ± 6.26

The 2002/03 growing season was preceded by a season of well above average long-term rainfall (54% more), which could have been responsible for the favourable seedling density occurring in 2003/04 (Figure 2). The decrease in seedling density from the 2003/04 season onward, with the lowest point reached during the 2005/06 season, can largely be attributed to the extreme dry 2003/04 and 2004/05 seasons (on average 19% less than the long-term average), when the grasses could not produce large quantities of seed. The above average rainfall of the 2005/06 season, which was 30% more than the long-term average, caused the increase in seed density when the grasses could supplement the seed source in the soil seed bank. Where the seed was removed, it caused a decrease in seedling density over all the years as expected (Figure 2). Those grasses which seeded showed a variable seedling density over the five years with a very favourable seedling density in the 2003/04 growing season.

Figure 2: Mean grass seedling density (number of live seedlings m-2) for the clipping treatment for the 2002/03 to 2006/07 growing seasons. Vertical bars are standard errors of means.



Discussion

This study clearly showed that the longevity of the Decreaser grass species was very poor as after only four years of seed removal, no more seed was present in the seed bank. The results of seed removal support the contention that *Themeda triandra* is prone to failed seedling recruitment under sustained defoliation, because of elimination of the seed bank (O'Connor 1994). In contrast, *Themeda triandra* showed considerable annual seed turnover when the seed was not removed. If Decreaser grass species cannot seed for whatever reason in this semi-arid grassland, the potential of the seed bank decreases linearly until it is suddenly depleted after four years. At that time, only 11 out of 27 grass species were present in the seed bank in the field where seed was permanently removed, of which the remaining grasses were those with very small seeds. According to O'Connor (1997) *T. triandra* does not have a seed bank older than one year, which is debatable when compared with these results. In a Montana grassland of South Africa, a high predation of seeds (70-98%) and low viability (37% in 15-

month-old seeds) contributed to poor representation of T. triandra in the seed bank (<1.2%) when compared with the aboveground vegetation (<29.2%; Everson et al. 2009). These attributes, together with its poor dispersal, indicate that seed dynamics of *T. triandra* will play a limited role in the restoration of grassland in degraded areas (Everson *et al.* 2009). The availability of seed therefore depends on seed production by the established population in the preceding year (O'Connor and Pickett 1992) and also the maintenance of its viability in the seed bank over time. The paucity of seed carry-over by grasses from season to season has also been reported by Russi et al. (1992).

The *Eragrostis* species, especially *Eragrostis. chloromelas,* still had a good seedling emergence in the seed bank after four years of removing the seed from the plants. These very small seeds of the *Eragrostis* species therefore have a good survival ability. The dominance of *Eragrostis* species after four years in the seed bank is supported by studies finding that small seeds, like those of *Eragrostis spp.* dominated as they are more persistent because they can bury into the soil faster and escape predation (Snyman 2004; Fenner and Thompson 2005). According to Jones (1968) sub-climax grasses such as *Eragrostis* can yield an immense quantity of seed (up to 21 000 seeds m-2). Perennial grasses, especially the larger-seeded species, do not, in general, form persistent seed banks even in the absence of seed predation, because of poor seed survival (Williams 1983). Snyman (2004) also argued that the larger a grass seed the shorter its longevity.

The seedlings of the seed bank mainly consisted of forbs as well as early succession species, while those established in the field were more dominated by climax plants. The disturbed habitat of the greenhouse seedlings was therefore more beneficial for species with a lower ecological status. The same explosion of pioneer plants is found in practice when soil is cultivated or mechanically disturbed for the first time (Snyman 2003). Climax plant species therefore prefer a more natural and undisturbed habitat for successful establishment and survival (Snyman 2003). According to Wolfson and Tainton (1999), the relative importance of seed to the survival of *T. triandra* populations varies according to the ecological conditions of the site. Seeds of perennial grasses are usually scarce in the soil and this would explain, at least partly, the slow recovery of disturbed perennial rangelands (Snyman 2004). Not only did the Decreaser species decrease drastically after four years of seed removal, but so did the species richness.

Conclusion

This study clearly demonstrated that the composition of the seed bank depends on the composition and production of the present and previous plant communities, as well as on the longevity of the seeds of each species under local conditions. If there is a disturbance to the plant community, the seed bank might intervene in re-establishing the original community. This relationship between the composition of the seed bank and the vegetation is particularly important for the vegetation that appears under different management regimes.

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The effect of planting date on the dry matter production of annual forage sorghum hybrids and hybrid millet cultivars.

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Introduction

The use of forage sorghum hybrids (*Sorghum bicolor* (L.) Moench x *Sorghum sudanense*) (Viaene and Abawi 1998) and hybrid millets (*Pennisetum glaucum*) as summer and autumn pasture have became very popular during recent years. This is because forage sorghums hybrids and hybrid millets have low water requirement, high dry matter (DM) productions and rapid growth over a short season (Renato *et al.* 2001, Butler *et al.* 2003). Unfortunately no information is available on when to establish these pastures and if some cultivars can be planted earlier than others. It is important during establishment to choose the most effective planting date to ensure optimal growth. The wrong planting date could lead to insufficient germination and uneven growth.

The aim of the study was to determine the effect of planting dates of different cultivars on dry matter production of forage sorghum hybrids (*Sorghum bicolor* (L.) Moench x *Sorghum sudanense*) and hybrid millets (*Pennisetum glaucum*).

Material and methods

An experiment using four different planting dates was conducted at Outeniqua Experimental farm with forage sorghum hybrids and hybrid millet cultivars. The farm is situated near George in the Western Cape (altitude of 210 m, 33° 58' 38" S and 22° 25' 16" E,) (Botha 2003) with an annual rainfall of 730 mm.

Ten cultivars were selected according to previous sorghum trail results (Gerber *et al.* 2006). The cultivars were planted at four different planting dates. The planting dates were 22 September 2006, 20 October 2006, 21 November 2006 and 20 December 2006. Table 1 indicates the different types of forage sorghums hybrids and hybrid millet cultivars that were selected.

Table 1: The types of forage sorghum hybrids and hybrid millets and cultivars evaluated

Type of sorghum	Cultivar
Conventional:	
Late	Jumbo Pac 8288
Early	Greengrazer Super King
BMR	Revolution BMR Kow Kandy BMR
Sweet	Hunnigreen Betta Grazer
Hybrid millet (Pennisetum)	Hy Pearl Millet Nutrifeed

The cultivars were planted on an Estcourt type of soil. Sixteen paddocks sized 138 m² each was divided into 10 blocks. The size of these blocks was 11.5 m². Soils were sprayed with glyphosate (2 L/ha) 2 weeks before planting. Soils were tilled with a disc harrow (1.5m) followed by a kongskilde. Seeds were broadcasted on plots and then rolled with a land roller (2.33m width, 30 rollers, Cambridge type). The seeding rate of forage sorghums hybrids and hybrid millets were 30kg/ha and 15kg/ha respectively. Irrigation was scheduled according to a tensiometer reading. Irrigation commenced at a tensiometer reading of –25 Kpa and terminated at –10 Kpa (Botha 2003). Fertilizer was applied to raise the soil potassium (K) level to 80mg/kg, phosphorous (P) to 35mg/kg and pH (KCl) level to 5.5. Nitrogen (N) and potassium (K) was applied before planting at a rate of 50kg LAN/ha and 150kg KCl/ha respectively. Four weeks after emergence a top dressing of 200kg/ha of 4:3:4 (33) was applied and after each cutting 200kg/ha LAN. and 90kg/ha KCl were given.

Plants were harvested when 60% of plots reached a height of 1 meter. It was cut down with an Agria 5400 cutter (1.27m width) to a height of 100 mm. Sorghums were separated from weeds to determine plot weight. Samples of approximately 300g were taken from each plot to be weight and dried for 72 hours at 60° C, this was used to determine DM production (kg DM/ha), growth rate (kg DM/ha/day) and DM content (%).

The experimental design was a split-plot with 4 main plot treatments (planting dates) and 10 split plot treatments (cultivars). To select the treatments, which performed the best, a monthly average was calculated for each variable. An appropriate analysis of variance was conducted. Student ‘s LSD (least significant difference) at a 5% significance level was used to compare the treatment means (Ott 1998) The assumption of normality of the residuals was tested by a Shapiro Wilk test before the analysis of variance could be called reliable and valid. The “LSTATS” module of SAS program version 8.2 was used to analyze the data (SAS 1999).

Result and Discussion

Table 2: The total DM production (kg DM/ha) of frequently cut forage sorghum hybrids and hybrid millet cultivars planted during September 2006.

Cultivar	1st cutting 11 Dec	2nd cutting 8 Jan	3rd cutting 6 Feb	4th cutting 12 Mar	5th cutting 25 Apr	**Total DM production**
Betta Grazer	440[a]	1615[a]	1854[a]	1054[ab]	1446[a]	**6409[a]**
HyPearl Millet*	67[e]	453[cd]	940[cd]	608[cd]	644[cd]	**2712[cd]**
Nutrifeed*	117[cde]	803[bc]	1681[ab]	1168[a]	1373[a]	**5142[ab]**
Pac 8288	265[bc]	1204[b]	1767[a]	1171[a]	1175[ab]	**5582[ab]**
Greengrazer	281[b]	1143[b]	1609[ab]	837[abc]	973[bc]	**4843[ab]**
Super King	228[bcd]	1007[b]	1155[bc]	790[bc]	896[bc]	**4076[bc]**
Revolution BMR	46[e]	382[d]	322[e]	180[e]	151[e]	**1080[e]**
Kow Kandy	12[e]	226[d]	74[e]	23[e]	35[e]	**369[e]**
Hunnigreen	78[e]	502[cd]	371[de]	134[e]	162[e]	**1247[de]**
Jumbo	83[de]	531[cd]	580[cde]	351[de]	327[de]	**1872[de]**
LSD (0.05)	148.2	402.5	586.9	345.8	347.5	**1618.5**

[abcde] Means with no common superscript differ significantly (P<0.05)
Hybrid millet*

Betta Grazer produced the highest amount of DM during the first two cuttings. During the third and fourth cutting Betta grazer, Nutrifeed, Pac 8288 and Greengrazer produced similar amounts of DM. This resulted in Betta Grazer, Nutrifeed, Pac 8288 and Greengrazer to produce the highest total amount of DM per hectare (kg/ha).

Table 3: The total DM production (kg DM/ha) of frequently cut forage sorghum hybrids and hybrid millet cultivars planted during October 2006.

Cultivar	1st cutting 19 Dec	2nd cutting 18 Jan	3rd cutting 16 Feb	4th cutting 27 Mar	5th cutting 14 May	**Total DM production**
Betta Grazer	711[a]	1357[a]	1330[a]	2128[a]	604[b]	**6131[a]**
Hy Pearl Millet*	206[d]	725[d]	667[de]	1145[c]	401[bcd]	**3145[de]**
Nutrifeed*	379[cd]	995[c]	1243[ab]	1909[ab]	1279[a]	**5805[a]**
Pac 8288	694[a]	1257[ab]	1498[a]	2044[a]	559[bc]	**6052[a]**
Greengrazer	462[bc]	1037[bc]	919[bcd]	1525[bc]	404[bcd]	**4346[bc]**
Super King	631[ab]	1031[bc]	1124[abc]	1796[ab]	544[bc]	**5125[ab]**
Revolution BMR	303[cd]	747[d]	480[ef]	636[d]	194[de]	**2359[e]**
Kow Kandy BMR	198[d]	400[e]	114[f]	135[e]	42[e]	**888[f]**
Hunnigreen	250[cd]	575[de]	523[e]	546[d]	195[de]	**2090[e]**
Jumbo	446[bc]	1031[bc]	758[cde]	1133[c]	343[cd]	**3710[cd]**
LSD (0.05)	226.8	243.1	380.1	401.8	256.6	**1109**

[abcde] Means with no common superscript differ significantly (P<0.05)1
Hybrid millet*

Betta Grazer, Nutrifeed, Pac 8288 and Super King had high DM productions throughout the majority of the first four cuttings. Nutrifeed produced the highest amount of DM during the fifth cutting. This resulted in Betta Grazer, Nutrifeed and Pac 8288 to produce a higher amount of DM/ha than most of the cultivars and only Super King could produce a similar amount of total DM/ha.

Table 4: The total DM production (kg DM/ha) of frequently cut forage sorghum hybrids and hybrid millet cultivars planted during November 2006.

Cultivar	1st cutting 11 Jan	2nd cutting 8 Feb	3rd cutting 15 Mar	4th cutting 4 May	5th cutting	**Total DM production**
Betta Grazer	1314[abc]	775[b]	1032[a]	1172[bc]	-	**4293[bc]**
Hy Pearl Millet*	1456[ab]	1543[a]	751[bc]	1095[bc]	-	**4845[b]**
Nutrifeed*	1597[a]	1712[a]	795[ab]	1809[a]	-	**5913[a]**
Pac 8288	930[cd]	831[b]	1009[ab]	1264[b]	-	**4034[bc]**
Greengrazer	1031[bcd]	653[bc]	484[d]	654[de]	-	**2822[d]**
Super King	958[cd]	770[b]	779[abc]	1031[bcd]	-	**3538[cd]**
Revolution BMR	357[e]	374[c]	217[e]	326[ef]	-	**1274[e]**
Kow Kandy BMR	257[e]	398[c]	50[e]	74[f]	-	**780[e]**
Hunnigreen	264[e]	385[c]	194[e]	400[ef]	-	**1244[e]**
Jumbo	647[de]	621[bc]	528[cd]	804[cd]	-	**2599[d]**
LSD (0.05)	459.0	371.1	259.8	383.9		**1055.2**

[abcde] Means with no common superscript differ significantly (P<0.05)1
Hybrid millet*

During the first cutting Nutrifeed had a higher DM production than most of the cultivars and only Betta Grazer and Hy Peal Millet had a similar DM production. The fact that Nutrifeed had a higher DM production during each cutting than most of the other cultivars and only similar to that of Betta Grazer during the third cutting, resulted in Nutrifeed to produce the highest total amount of DM per hectare.

Table 5: The total DM production (kg DM/ha) of frequently cut forage sorghum hybrids and hybrid millet cultivars planted during December 2006.

Cultivar	1st cutting 1 Feb	2nd cutting 28 Feb	3rd cutting 17 Apr	4th cutting	5th cutting	**Total DM production**
Betta Grazer	1397[a]	924[b]	1536[ab]	-	-	**3856[abc]**
Hy Pearl Millet*	1051[ab]	1579[a]	1583[a]	-	-	**4213[ab]**
Nutrifeed*	1188[ab]	1686[a]	1700[a]	-	-	**4574[a]**
Pac 8288	954[b]	957[b]	1325[ab]	-	-	**3236[bc]**
Greengrazer	1219[ab]	818[b]	804[cd]	-	-	**2841[c]**
Super King	961[b]	875[b]	1050[bc]	-	-	**2886[c]**
Revolution BMR	229[c]	290[c]	284[e]	-	-	**802[d]**
Kow Kandy BMR	160[c]	148[c]	71[e]	-	-	**379[d]**
Hunnigreen	296[c]	319[c]	199[e]	-	-	**814[d]**
Jumbo	273[c]	394[c]	376[de]	-	-	**1044[d]**
LSD (0.05)	412.0	367.7	494.8			**1067.8**

[abcde] Means with no common superscript differ significantly (P<0.05)1
Hybrid millet*

Hy Pearl Millet and Nutrifeed produced similar amounts of DM during each of the three cuttings followed the December planting date. The similarity of DM produced by Betta Grazer compared to that of Hy Pearl Millet and Nutrifeed during the first and third cut resulted in these three cultivars to produce a higher total amount of DM per hectare than most of the cultivars.

Table 6: The total DM production (kg DM/ha) of frequently cut forage sorghum hybrids and hybrid millet cultivars planted on 4 different planting dates.

Cultivars	22 September	20 October	21 November	20 December
Betta Grazer	6409[xx]	6131[x]	4293	3856
Hy Pearl Millet*	2712	3145	4845	4213
Nutrifeed*	5142	5805[x]	5913[x]	4574
Pac 8288	5582[x]	6052[x]	4034	3236
Greengrazer	4843	4346	2822	2841
Super King	4076	5125	3538	2886
Revolution BMR	1080	2359	1274	802
Kow Kandy	369	888	780	379
Hunnigreen	1247	2090	1244	814
Jumbo	1872	3710	2599	1044
[1]LSD (0.05)	**1618.5**	**1109.0**	**1055.2**	**1067.8**
[2]LSD (0.05)	**1193.0**			

[1]LSD within planting date
[2]LSD over planting dates
[xx]Highest value ($P<0.05$) LSD = 1193.0
[x]Differ not from highest value ($P>0.05$) LSD = 1193.0
Hybrid millet*

Betta Grazer planted during September produced a higher amount of total DM than most of the other cultivars. Only Pac 8288 planted during September or October, Nutrifeed planted during October or November and Betta Grazer planted during October could produce a similar amount of DM than Betta Grazer planted during September.

Conclusion

Cultivar had a significant influence on DM production. Betta Grazer, Nutrifeed, Pac 8288, Greengrazer, Hy Pearl Millet and Super King were the most prominent cultivars and produced a higher total DM production than most of the other cultivars if compared to planting date and the frequency of cutting. Betta Grazer, Nutrifeed and Pac 8288 are recommended for the September and October planting date, Nutrifeed for the November planting date and Nutrifeed, Hy Pearl Millet and Betta Grazer for the December planting date.

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Feature

The effect of *Acacia Mearnsii* removal on water table fluctuations in the Tsomo valley Eastern Cape of South Africa

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Introduction

Invasive trees alter and utilize more water compared to indigenous trees because of their higher transpiration rates per unit leaf area (Enright 1999). Recent climate-soil-vegetation modeling suggests that, given the same soil type between forested and bare soil conditions, forested soils have higher moisture losses (about 30% more) from evapo-transpiration than bare soils (Zhang and Schilling 2006). This results in forested soils producing less groundwater recharge than bare soils.

Introduced vegetation changes the surface characteristics of habitats through altering plant to plant interactions (Dye and Jarmain 2004). They significantly influence soil water balance as they increase in dominance (Le Maitre *et al.* 2000); and alter soil water balance through shifts in phonological schedules (Luken and Thieret 1997).

In semi-arid savanna ecosystems, the suppressive effect of an increase in woody plant density on herbaceous plants, mainly grasses, is largely through competition for soil water (Smit and Rethman 1999). If a plant is introduced in an ecosystem, it will have seasonal pattern of canopy formation and physiological activity differing from the native species in the community (Enright 1999). Such differences lead to degradation of ecosystem resources. Invasives are very competitive as shown by Melaleuca quinquenervia which is a very prolific rooter regardless of competing vegetation in the Netherlands (Lopez-Zamora *et al.* 2004). *Melaleuca quinquenervia* develops root densities greater than many mature native species at an early age and in the soil surface during soil drying periods, even while competitive grasses are dying out (Lopez-Zamora *et al.* 2004).

Salt cedar (*Tamarix ramosissima*) is a great consumer of water in Russia; a single large plant can absorb 100 liters of water a day (Friedmanm 2000). This results in the lowering of the ground water, drying up of springs and marshy areas, as well as reduction in water yield of riparian areas. Experiments aimed at assessing the effects of clearing on groundwater have not been adequately integrated with other components of the hydrological cycle in modeling of groundwater dynamics (DWAF 1997).

The reasons for increased water use and whether such increases should be expected from all species of invading alien trees under all environmental conditions are not well understood (Calder and Dye 2001). The few South African catchments and evaporation studies that have yielded water use data so far are too few to provide an adequate foundation for the countrywide estimation of evaporation in invaded regions (Calder and Dye 2001). The objective of the study was to quantify the water table fluctuations due to presence of *Acacia mearnsii.*

Experimental layout and data collection
The field experiment was a complete randomized design with two replicates. Two treatments were tested: (a) presence of *Acacia mearnsii* trees (b) absence of *Acacia mearnsii* trees. There were a total of four experimental units. Four plots, measuring 20m x 10m each, were selected based on the presence of natural wells. The plots were largely dominated by clayey-loam soils. Clearing of *Acacia mearnsii* trees was done using chain-saws in September 2007 so as to start the recordings in November, when the rains start falling. In doing so a cyclic comparison in fluctuations would be obtained to compare between the wet and dry period. Infiltration rate, as affecting water seepage and water table level, was measured using the Double ring infiltrometer. Weather variables such as rainfall were monitored using a local weather station.

In each of the four plots, a Data Logger (HOBO Pro U20-001-03, 250-Foot Data Logger, Onset, 2005) machine was installed at a depth of 90cm to estimate the changes in the level of water table. The Data loggers were measuring daily temperatures, atmospheric pressure and the change in water storage from the natural wells in ºC, KPa and meters respectively, within a radius of 20 meters. The data loggers were set up to record the above parameters every 15 minutes and the data was retrieved from the machines at two week intervals and then averaged over a month.

Data analysis
All data sets were subjected to normality test to ascertain compatibility with assumptions of analysis of variance. The F test was conducted as appropriate for randomized complete design with the generalized linear model of SAS (SAS 1999). Pearson's Correlation coefficient was used to establish the relationship between the variables with change in water storage. The data were split to wet and dry season. The equation adapted from Loheide *et al.* (2005), Dunne and Leopold (1978) was used to incorporate the variables that affected the water table fluctuations;

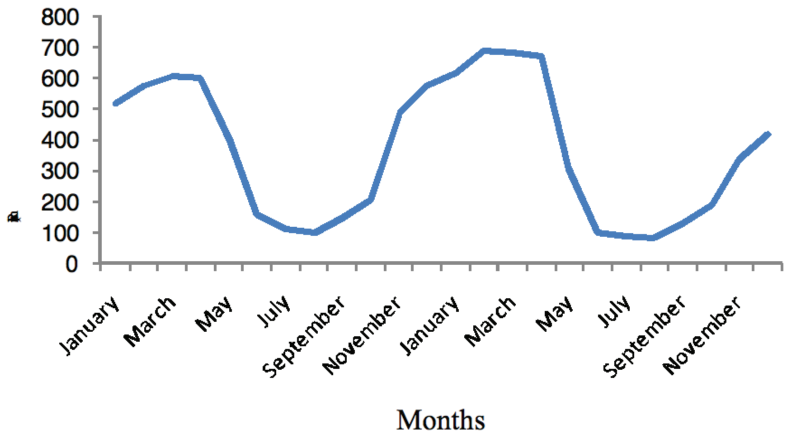
dS = (dW x specific yield – R) x A
Where change of water elevation (dW) represents the rise and fall in the level of the water table depth
dS= Change in storage
R=Rainfall
A=Watershed area

Specific yield is the volume of water released from storage per unit land surface area per unit drop in the water table. The specific yield can be estimated based on sediment texture of the soil when the depth to the water table is above 1 m (Loheide *et al.* 2005). These values are based on the assumptions that the water table is deeper than 1 m, and that the readily available specific yield is essentially independent of the magnitudeof the diurnal fluctuations and antecedent moisture conditions. The watershed area for Elliot was estimated from the digitalized elevation model.

Results
Effective management of groundwater resources requires information about all components of the water budget and the water table level is essential as it affects groundwater accessibility by vegetation. The water table is important because it provides moisture in the soil for vegetation to utilize readily. The closer the water table level is to the surface, the easier the access vegetation will have to the water. The proximity of the water table and the fluctuation of the water table over time, have a substantial influence on the type and productivity of plant communities.

As expected, rainfall during data collection constantly increased from November (2007) to February (2009), Rainfall received decreased gradually from February 2008 to June 2008 (Figure 1).

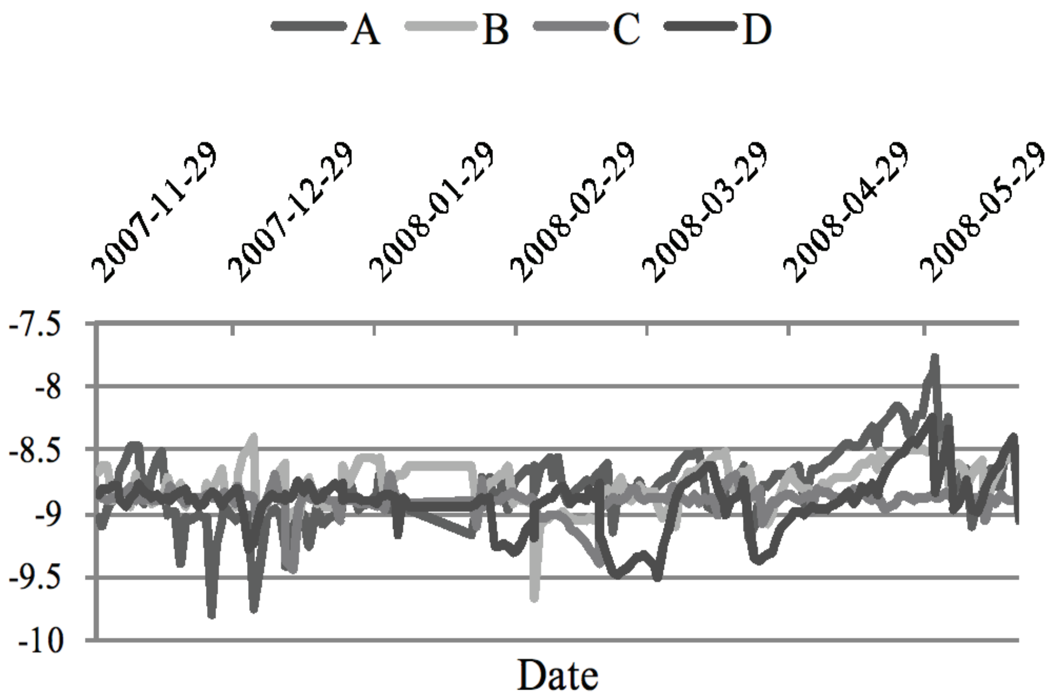
Figure 1: Rainfall amount received during data collection period (January 2007-December 2008)



In this study, the fluctuation of the change in water table storage from November (2007) to May (2008) did not vary significantly (Figure 2). The wet and the dry period recorded a significantly different change in water storage (-9.35 m and -8.8 m respectively), as expected, (Figure 2). The change in storage for the wet period showed a constant increase as the months progressed while a slight change in storage is seen between the first and third months only and, thereafter, a constant decrease occurred to the last month of the dry period (Figure 2.)

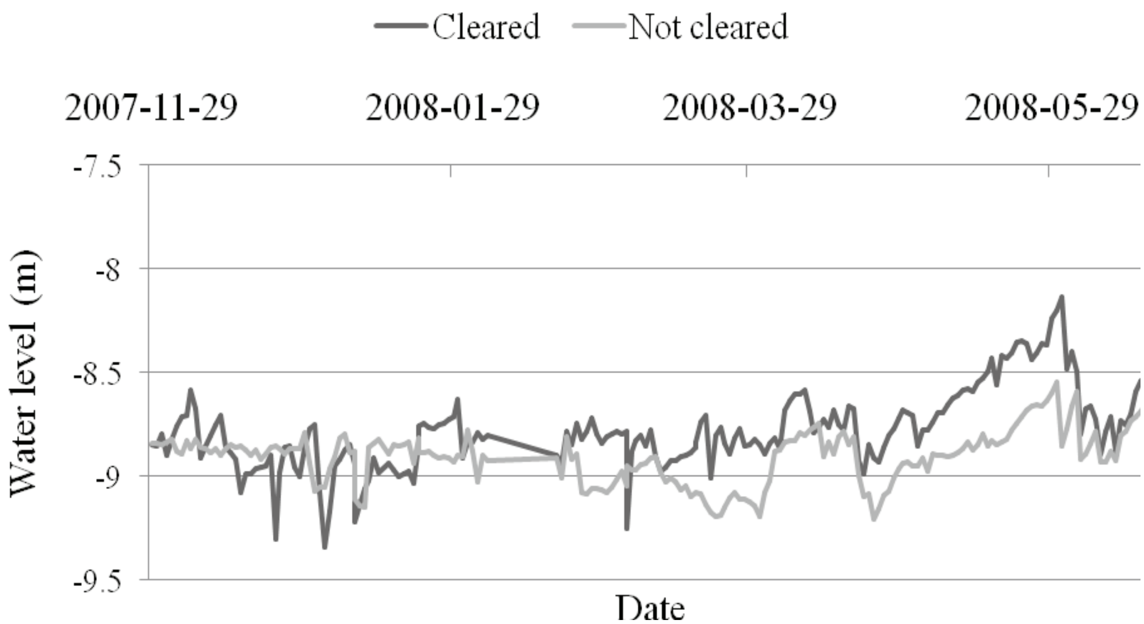
Water table fluctuations did not show significant differences when comparing the four data loggers (Figure 2). The data showed that cleared plots averaged higher (-9 m) than not cleared plots (-8.7 m) during the recording period (Figure 2). The fluctuations from the data loggers are more defined during the wet period of data collection (Figure 2).

Figure 2: Water table fluctuations from the four data loggers. A and D represent fluctuations measured in cleared plots while B and C represent fluctuations measured in non cleared plots.



Water table fluctuations are less defined during the initial months of the wet period but the difference between the fluctuations is however clearly defined and visible as the wet season approaches its end (February and March) (Figure 3). Water table recharge increases in the cleared plots as the water fluctuates towards positive levels compared to the not cleared plots (Figure 3). Differences between fluctuations are minimal during the initial stages of the wet period when comparing the cleared and not cleared plots but become clearer as the months progress, becoming clearer and, therefore, higher during the dry period (Figure 3).

Figure 3: Effects of clearing A. mearnsii on water level fluctuations



The water table fluctuation was positively correlated to the total biomass production in the plots (r = 0.121; p > 0.05), whilst water table fluctuation was also correlated to the basal cover (r = 0.326, p < 0.05). The infiltration rate was not correlated to the change in water table storage. Infiltration rate was significantly and positively correlated to the change in water storage (r=0.56, p < 0.05) for the cleared plots while infiltration rate was insignificantly correlated (r=-0.93, p > 0.05) to the change in water storage in the not cleared plots.

Discussion

Acacia mearnsii caused a reduction in water table in plots not cleared as it has high biomass production that in turn, leads to increased maintenance requirements for water and nutrients. Water table fluctuations in cleared plots increased water table recharge because clearing trees reduced water uptake by vegetation. These results are similar to Prinsloo and Scott (1999) in South Africa (Western Cape) where there was 12m-3day-1ha-1, 10.4 m-3day-1ha-1 and 8.8 m-3day-1ha-1 increase in stream flow after clearing Acacia mearnsii and Acacia longifolia in Knorhoek, Oaklands and Du Toitskloof in the Western Cape .

The invasive *Acacia mearnsii* reduced groundwater recharge through altering interception, infiltration, surface runoff, transpiration through the use of their deep rooting system. This also allowed A. mearnsii to utilize that water that would have ended up in rivers or streams instead. The presence of A. mearnsii affected water recharge by directly extracting groundwater from saturated strata and reducing the proportion of rainfall that eventually recharged by interfering with the passage of precipitation from the atmosphere to the water table in the soil.

Acacia mearnsii decreased water table recharge because it was extracting soil water in the unsaturated zone through its roots, to feed transpiration, thereby decreasing amount of percolating water that reached the saturated zone. Water tables can fluctuate considerably due to seasonal and annual changes in inflows of water and as expected the wet season had higher mean moisture water table recharge compared to the dry season due to the higher rainfall amounts received during the wet season. Plant water use varies within and between days, as well as within and between seasons. Therefore such a variation between seasons was expected for this study.

Tree harvesting, like the plots that had *A. mearnsii* cleared, changes the rate of transpiration as leaf area is reduced causing reduced water use by the tree. Therefore clearing *A. mearnsii* reduced total leaf area thus increasing water storage in the soil. *Acacia mearnsii* reduced water storage where there were trees and this may have been due to that *A. mearnsii* increased the bulk density of the soil, thereby reducing soil porosity. The less the soil was porous, as expected, the low the water quantity that would percolate.

The water received through rainfall was higher in the wet season than that utilised by the trees leading to an increased recharge of the water table. The results of this study are similar to those of Khanzada et al. (1998) when the water consumption by Acacia nilotica and Acacia ampliceps increased during the dry period of their study and was not significant in the wet season due to rainfall received. For most rainfall events there is a rise in water table level. Water infiltrates directly from the surface to the water table and rises in the water level, therefore, occur very quickly. Rainfall thus plays a critical part in evaluating the groundwater levels.

In the summer when most of the rainfall events occur, the trees are in a growth stage and the temperature is high the outflow will be positive. In winter months the contribution of these elements are minimal and it would be expected that with no, or very little, rainfall no outflow would occur but the fractured gneiss in the catchment slowly releases water into the system.

Infiltration rate was positively correlated to the change in water storage in the soil, most likely because a higher infiltration rate results in increased water percolation, thereby increasing the water table level. Infiltration rates from the cleared plots were higher than those from the not cleared plots due to the differences in soil porosity. The soil from the cleared plots was more porous as observed from its infiltration rate as compared to the not cleared plots. *Acacia mearnsii* bound the soil particles together in the plots not cleared thereby reducing the porosity of the soil.

A rise in water table increased the total biomass production in the plots that were cleared of *A. mearnsii* because clearing the plots reduced the amount of water loss through evapotranspiration and this water was instead utilized by the vegetation growing where *A. mearnsii* had previously grown. The basal cover also increased with an increase in water table recharge due to a reduction in water loss through evapotranspiration by trees, a similar observation to the total biomass observation.

Conclusion

Acacia mearnsii had a negative effect on water table recharge because the change in water storage was lower for the plots that had trees compared to the plots that did not have trees. The wet season recorded minimal water loss from the water table due to the rainfall received compared to the dry season. Invasion of rangelands by *Acacia mearnsii* therefore, causes serious threats to vegetation development because it converts water meant for utilization by native vegetation to its own use. The depression of water tables through consumptive use of water by invasive trees like *A. mearnsii* can lead not only to a reduction in available water, but also to a corresponding decrease in species diversity.

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