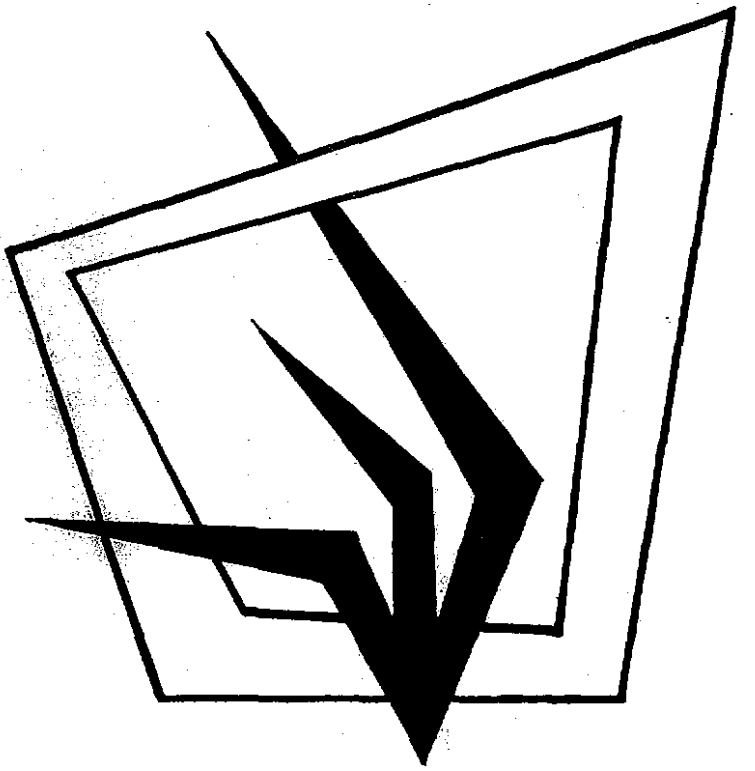
BULLETIN OF THE GRASSLAND SOCIETY OF SOUTHERN AFRICA



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BULLETIN OF THE

GRASSLAND SOCIETY OF SOUTHERN AFRICA

Volume 5 (1) **January 1994**

CONTENTS

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EDITORIAL

SEASONS' GREETINGS FOLKS!

Just a bright, cheery, greeting to all the learned folk out there - pity we are not hearing more from you! Your attention is drawn to the "Progress made with the strategic plan for the GSSA, 1993" article and in particular the point under "Action 2" which states "... the scope of the bulletin will be expanded to allow...articles and papers of a more speculative nature and...provide... a forum for debate and exchange of ideas". Submissions to this bulletin are hence invited.

Contributions may take the form of:

* feature articles;
* research updates;
* news and points of view ;
* practical or technological information of interest or usefulness;
* research programme proposals and reports;
* brief reviews of new (or old and forgotten) books which have been or help;
* details of relevant conferences, workshops and training courses; and,
* basically, any other grassland science related activity.

Is anybody actually doing anything out there? What methods are working or, better still, not working out there?! Remember this is your bulletin, so use it to tap into a wider network or use it as a springboard for those ideas others may see as being eccentric, radical, impractical or over ambitious. Technology, mathematical and statistical techniques are merrily rocketing along no doubt leaving most of us behind. Does anyone have a 'road-map' to guide one through the maze of vegetation survey techniques available or what of a 'toolbox' of statistical methods?

We would welcome articles describing your experimental 'flops'. Here we do not mean those trials that failed to get a three star rating ($P<0.001$) - these should be reported in the journal anyway - but those experiments where things went wrong. A new technique may not have worked or a particular sampling strategy may not have been as appropriate as one hoped. You will save a lot of people a lot of heartache and backache if you warn them now. We can learn more from our failures than our successes (which may explain why some of us, particularly in Natal, are so wise in recently losing the hallowed rugby Currie Cup!).

The bulletin will gladly publish results from trials where the methodology may have turned the references pale (perhaps because treatments were not replicated 15 times and run over 100 years). If the results confuse you then send them to us and we will publish them for you to a wider audience through the bulletin. After all, communication is the name of the game and any experimental results deserve their fair exposure. Let us hear from you!!

Congress 29 is to be held in Harare, Zimbabwe, from 17 - 21 January 1994. Abstracts of papers and poster presentations for the congress form the bulk of this volume and the tireless efforts of Richard Hurt in processing the abstracts is gratefully acknowledged. Judging by the abstracts, the congress promises to be a good one.

That's all for 1993 folks. Have yourselves a Merry Christmas & a Prosperous New Year and do not forget to send in your contributions to the bulletin in 1994! (Note that the deadline for the next issue of the bulletin is 2 May 1994).

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OBITUARY

Dr. Raymond W. Brougham (1926 - 1993)

Dr Ray Brougham died suddenly in Palmerston North, New Zealand, on Sunday 24 October, while taking one of his regular walks through the city.

Born in Palmerston North in 1926, Ray completed his schooling in Palmerston North and, when working as a clerk for the local power board in 1945, had a chance encounter with DSIR Grasslands director Bruce Levy, who gave him a job as a casual labourer at the DSIR. This launched him on his career in grasslands. In 1947 he was given leave to study for the B.Sc. at the University of Canterbury, from which he graduated in 1950. Following this, he was appointed to the research staff of the DSIR, and during the 1950s and 1960s undertook much significant research into pasture establishment and grazing management.

Ray was appointed chief pasture ecologist at Grasslands in 1961 and was awarded the D.Sc. degree by the University of Canterbury in 1963 for his work on pasture ecology. He continued his study of grazing management concepts, particularly those related to the production of bull beef off pasture, through the 1970s even while carrying the post of Director (a position to which he had been appointed in 1971). This work contributed significantly to the development of this industry in New Zealand. He retired from the position of Director in 1986, having by this time published a hundred scientific and technical papers, spent many hours with farm discussion groups, at farmers' conferences and with industry, considerably expanded the research facilities of the grassland research organisation throughout New Zealand and done much to stimulate work on turf culture (he was President of the NZ Turf Culture Institute for close on a decade and later an Honourary Life Member, as well as being an Honourary Editor of the NZ Turf Journal).

Ray developed strong international links throughout his career and on retirement actively consulted for FAO and the World Bank. He has, for example, had a major involvement in land development projects in mainland China, which he last visited as recently as August this year. These links culminated in his Presidency of the 17th International Grassland Congress held in Australia and New Zealand in 1993, a congress regarded by many to be the most successful congress yet held by this organisation.

We in southern Africa have also, of course, benefitted from his considerable expertise. In 1984 he was invited by the South African Ministry of Agriculture to assess the research programmes and the general structure of the agricultural research organisation of the Department of Agriculture. His report on this investigation has served as a blueprint for developments since that time, which have included the formation of the Roodeplaat Grassland Institute and a considerable increase in both funding and staffing of the discipline of Grassland Science. He returned again to South Africa in 1991, where he participated in our prestige congress held in Pretoria. At this Congress he was elected an Honourary Member of our Society, but this was only one of a number of prestigious awards which he received during his lifetime. These included recognition as a Distinguished Grasslander by the American Forage and Grassland Council, the award of Honourary Membership of the New Zealand Grassland Association, the New Zealand 1990 Commemorative Medal and Membership of the Order of the British Empire.

Ray was, at the time of his death, assisting us with the organisation of a meeting of members of the 'Africa Committee of the International Grassland Congress' scheduled for the January congress of the Zimbabwe/southern Africa Grassland Societies. He had already secured international funding for the members of the Africa committee to attend this congress, and had promised his support for our efforts to host an International Rangeland or Grassland congress in Africa.

We will miss Ray's expert council at our planned meetings in Harare (to which he had been invited by our Society) and we will miss him in our future dealings with the international grassland fraternity. Above all, however, we will miss him as a true friend.

SOCIETY NEWS

PROGRESS MADE WITH THE STRATEGIC PLAN FOR THE GSSA, 1993

M.M. Wolfson, Roodeplaat Grassland Institute,
P/B X05, Lynn East, 0039

During the last AGM of the GSSA, the Council undertook to keep the members of the Society informed about progress with the implementation of the Strategic Plan for the Society. The following is a review of actions which have been initiated as well as those that are already being undertaken.

GOAL 1

To elevate the discipline as an essential profession

ACTIONS

- **Publish articles in the popular media**

  - For several years now Mr E.B. Dickinson has been preparing articles, based on papers published in the journal, for publication as "Grassland Gleanings". Initially, they were published in Die Boer, but more recently appeared in Rooivleis.

  - Professor Snyman has arranged for Mr A. Horn, press officer from University of the OFS, who has had experience in writing articles for the popular press, to prepare a proposal with regard to the writing up of the scientific articles as well as papers and posters presented at the Annual Congress, into a format for publication in the popular media.

- **Advertise in the popular media.**

- **Advertise GSSA at other conferences.**

  - A display has been prepared by J. Mynhardt, A. Moolman and K. van R. van Oudtshoorn with material contributed by GSSA members throughout South Africa, which will be used initially at the Schools Science EXPO. The display has however, been created in a format which will enable it to be transported easily and used at other venues.

  - A data base has been acquired providing information on other conferences, workshops etc to be held throughout Southern Africa in 93/94, thus facilitating the further use of this display.

- **Approach local wildlife society branches for opportunities to speak about veld etc.**

- **Use opportunities presented by drought to highlight importance of the profession**

- **Prepare and distribute a brochure describing the discipline**

  - A brochure has already been prepared and distributed by F. Hobson about the Grassland Society of southern Africa.

- The schools and tertiary education subcommittee is busy preparing a pamphlet designed to inform young people and potential grassland scientists about the GSSA and the discipline of Grassland Science.

- C. Fabricius is planning a project to produce a series of information pamphlets on "Sustainable Range and Forage Management in Southern Africa" covering aspects such as:
  - the causes and effects of overgrazing,
  - the consequences for the farmer and for future generation,
  - the benefits of sustainable range management to the land owner.

The expertise of different members of the GSSA in the management of moist grassveld (Natal), sweet grassveld (OFS), sour grassveld (Highveld), savannas, Valley Bushveld, and Karoo etc will be used in the production of these pamphlets.

- **Focus on contact with schools, undergraduates and graduates.**

  - A pamphlet for schools and students is being prepared in conjunction with University Grassland Science and Botany Departments. The Technicons and Agricultural Colleges will also be approached to become involved. Some of those already approached have responded enthusiastically and there have even been offers of assistance with the financing of the pamphlet with a request that advertising space be made available for the different educational institutions.

  - Participation in the Schools Science EXPO. (A report on the involvement of the GSSA will be published in the bulletin)

  - The Affirmative Action programme of the FRD has been approached for financial assistance for black students to attend the Annual Congress.

  - The possibility of the GSSA giving prizes for the best graduate student in Grassland Science is being discussed.

- **Create and publicise professional register**

  - The professional register has as already been created, and copies of the register will be made available.

- **Approach environmental control officers in corporate sector**

- **Work with extension officers**

- **Brainstorm new name and implications for Society.**

  - The general consensus obtained from the opinions expressed by members was that a change in name of the GSSA was not necessary especially if the GSSA is more widely advertised. However, the name of the journal has been changed.

- **Report back to members on major changes which may arise.**

  - Members are being kept informed of progress being made through reports appearing in the bulletin.

GOAL 2

To provide a home or support base for professional rangeland and pasture scientists

ACTIONS

- **Circulate current membership and professional registers**

  - Current membership registers are normally made available to members on an annual basis and the professional register will be circulated as soon as possible.

- **Issue membership certificates**

  - Once applications for membership are approved, members are being issued with membership certificates.

- **Hold regular annual congress**

  - The GSSA congress is being held on an annual basis.

- **Hold specialist symposiums**

  - Prestige Farmers' Days are serving as a forum for the specialist forums and to a certain extent the Pasture Farmers' Forum is also fulfilling this task.

- **Produce a journal of international standing - change name.**

  - The name of the journal has been changed to the "African Journal of Range and Forage Science".

- **Produce bulletin with expanded focus**

  - The editor of the Bulletin is aware of this need and it is hoped that the scope of the bulletin will be expanded to allow the incorporation of articles and papers of a more speculative nature and thus provide more of a forum for debate and exchange of ideas.

- **Develop International liaison**

  - liaison has been established with the Society of Range Management, particularly the group involved with Developing areas, through visits carried out by Council members and with Urs Kreuter who is based in the USA and is prepared to look after the interests of the GSSA.

  - Lists of referees have been exchanged with the SRM and the New Zealand Journal of Agricultural Science.

  - Professor Tainton is corresponding with possible African contacts and it is hoped that many of them will be attending the Conference in Harare where these contacts can be formalized.

  - Overseas referees are being used for some of the journal papers.

- **Introduce a dynamic management structure**

GOAL 3

To be an active facilitator, catalyst and co-ordinator for the rangeland and pasture industry

ACTIONS

- **Develop regional structures**

  This is being investigated at present by K. Kirkman who is preparing a proposal on this issue for discussion by the GSSA members.

- **Develop pasture farmers' forum**

  Aims, Objectives and future structure of the Forum will be discussed during the Farmers' Forum being organised during the 1994 Annual Congress

- **Hold workshops and demonstrations**

- **Continue Prestige Farmers' Days**

- **Establish 'Developing Areas' Branch**

  This has been established by G. Hatch - the Proceedings of the first meeting have already been published and the second meeting is planned for March 1994 in Lesotho.

GOAL 4

To make the Society more representative of the people, regions and range-use options in Southern Africa

ACTIONS

- **Seek actively to hold activities throughout the country**

  - Establish Regional structures?

- **Invite congress speakers from other parts of Southern Africa and other African countries**

  - The 1994 Annual Congress to be held in Zimbabwe is being attended by a number of African delegates.

- **Use relevant databases for broad contact and advertisement**

- **Circulate information on activities to relevant organisations**

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REPORT ON THE EXPO FOR YOUNG SCIENTISTS 30 SEPTEMBER TO 3 OCTOBER 1993

Jennifer Mynhardt, Roodeplaat Grassland Institute, P/B X05, Lynn East, 0039

The GSSA was privileged to take part in the Expo for Young Scientists which was held in the Sports' Centre at the University of Pretoria from 30 September to 3 October 1993. Twenty three regions including Swaziland were represented at the Expo. A total of 467 projects in 39 categories were entered. Of these, 9 categories involved Biological Sciences, Agricultural Sciences, Environmental Sciences and Ecology. Anneline Moolman, Jennifer Mynhardt and Karen van Oudtshoorn, representing the GSSA, were responsible for the evaluation of projects relating to Grassland Science. Judging was based on the scientific work and effort that went into preparing the exhibit, initiative shown and scientific method followed by the exhibitor, the quality of the exhibitor's findings and the scientific and technical skills that the exhibitor acquired during the study.

Even though the leaflets advertising the prizes offered by the GSSA were distributed fairly late in the year, we were delighted that at least one exhibit was related specifically to Grassland Science. The exhibit in the category Environmental Studies and Ecology was entitled "Ekobehoud of degredasie - die belangrike rol van veldkennis" was prepared by a 12 year old primary school pupil from the Sentrale Volksskool, Goldfields. Albert Geldenhuys, the exhibitor, was full of enthusiasm for his project and intensive questioning by the judges revealed his extraordinary understanding of the veld as a crucial resource as well as the importance of the correct management of this resource and the role it plays in the ecosystem. Albert's exhibit was composed of data collected during the past three years on his father's farm, interpretation of the data, photographs illustrating good and degraded veld, working models illustrating the effect of good veld management on seedling recruitment, herbarium specimens and seeds of different grass species as well as a written report on veld degradation problems and possible solutions. The emphasis of the whole project was on "veld knowledge" and the correct management thereof.

The decision of the judges that the project was of a high standard and expanded "vertically" well beyond the school curriculum was unanimous. The GSSA awarded a gold medal, cash prize and a book prize to this deserving student. (He also received a silver medal from the Department of Environmental Affairs). Although still young, Albert is very aware of the critical condition of the natural veld resources of Southern Africa and the need for immediate action. He also showed keen interest in and has already requested possible assistance from members of the GSSA in projects he has planned for the future.

The GSSA also had an exhibit at the Expo. An encouraging number of students, teachers, parents and other experts expressed interest in the work being undertaken by the GSSA and its members. The Society can look forward, with anticipation, to our participation in the 1994 Expo.

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CONGRESS 29 PAPER ABSTRACTS

This section contains the extended abstracts (arranged alphabetically by author) that were submitted and will be presented at the 29th Congress of the Grassland Society of Southern Africa at Harare, Zimbabwe. The abstracts have been edited to standardise format, but the text remains largely in the form submitted by the authors. Please note that certain abstracts were not received timeously for publication. I would like to express my thanks to Sandy Hobson for typing abstracts that were not received on disk.
Rich Hurt (Abstracts Editor, Congress Programme Subcommittee)

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Rhizosheaths: their development in response to the environment and aspects of their functions

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Rhizosheaths are sandy coatings which cover the entire length of each root of certain grass species. They consist of a mass of sand and silica particles embedded in a mucilaginous layer and are matted together by a meshwork of epidermal hairs. A review of the literature showed that rhizosheaths occur typically on grasses in dry, sandy soil. This implied that sheath development is a facultative response to these conditions. However, information available on rhizosheaths is limited, especially with respect to South African grass species. Most of the work done on rhizosheaths was anatomical and little functional data are available. A study was undertaken to investigate the influence of environmental conditions on the presence and extent of rhizosheath development and to gain information on their possible functions in terms of nutrient uptake, particularly in low nutrient environments. A survey of herbarium specimens revealed that the presence of rhizosheaths is a genetically fixed trait, occurring in the majority of South African grass species. The extent to which sheaths develop (the thickness of the sheath and the degree to which the soil particles are bound within the sheath), varies between, as well as sometimes within, species. Growth experiments were undertaken in order to determine whether this variation in the extent of development was a facultative response to environmental conditions. Seeds of three sheath-forming grass species which occur in South Africa, *Anthephora pubescens*, *Digitaria eriantha* and *Eragrostis pallens*, were grown under different conditions of soil texture and water/nutrient availability. Sheath development was found to be more extensive the higher the sand (relative to clay) content in the soil. In addition, rhizosheaths developed to a greater extent on individuals growing in conditions of high water and nutrient availability. Therefore, the extent to which rhizosheaths develop is a facultative response directly to sandy soil, rather than the resulting lower water/nutrient availability of this soil. Sandy soil has a low nutrient availability relative to clay soil, due to its limited ability to hold nutrients against leaching, as well as its relatively lower water content. The presence of rhizosheaths may function to compensate for low immobile ion availability. The influence of sheath thickness on nutrient uptake was investigated by stimulating within-species variation in sheath thickness and measuring the difference in phosphorus uptake. The individuals with thick sheaths extracted more phosphorus from the soil, and from a greater volume of soil, than individuals with thin sheaths. This was particularly evident in conditions of low phosphorus availability. Although rhizosheaths do not develop in response to low water and/or nutrient availability this study provides evidence that they may compensate for low phosphorus availability. This compensation is possibly a result of the close proximity of epidermal hairs, mucilage and soil particles which arises as a consequence of rhizosheath formation and facilitates easier nutrient/water uptake by roots.

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The evaluation of the stability of fynbos patches by means of remote sensing

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A long-term study is being undertaken to investigate the effect of conservation and resource management on certain fynbos vegetation types in the south-western Cape. The response of the vegetation is evaluated over a number of years by using remotely sensed images. Fractal theory is applied by evaluating the size, distribution and shape of the fynbos patches in order to obtain a measure of the stability of the vegetation. This technique, which has successfully been applied in ecological studies, is described in this paper, and preliminary results are presented which indicate that the technique may aid the optimization of scale-dependent operations in conservation management.

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Effects of stocking rate on irrigated pastures of kikuyu grass (*Pennisetum clandestinum* Chiov.) and Kenya white clover (*Trifolium semipilosum* Fres.) in Zimbabwe

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Pastures of kikuyu grass and Kenya white clover growing on a sandveld soil at Marondera, Zimbabwe (18° 11'S) were irrigated as necessary between mid-August and mid-May and grazed by yearling steers at stocking rates of 3.7, 7.4, 11.1 and 14.8 steers ha^{-1} from mid-October until livemass losses were recorded (usually June). In two of the four years of the trial, irrigation was curtailed by shortage of water; in year 3 from January onwards and in year 4 until March (grazing in year 4 started only in early December). Grazing rotations with 3 and 6 paddocks, both with twice-weekly moves, were also compared, but had little effect and all results are therefore presented as means for the stocking rate treatments. The amounts of herbage on offer and the percentages of clover in that herbage were estimated before the start of grazing in each season and at approximately two-month intervals thereafter. Marked effects of stocking rate on herbage availability were obvious at all but the pre-grazing samplings. Especially on the lightly-stocked treatments, considerable herbage (in one case 10 t DM ha^{-1}) remained when the steers started to lose livemass and available herbage at that time was almost invariably greater than at the start of grazing. At the pre-grazing samplings, the percentage of clover increased with increasing stocking rate, and this trend became more distinct as the trial progressed. There also appeared to be a trend for the percentages of clover in the pre-grazing samples to decrease each year, but this was confused because percentages of clover at the start of grazing in year 2 were aberrantly low. Once grazing started, the percentages of clover decreased and differences due to stocking rate were generally small and not readily interpretable. The steers were weighed at fortnightly intervals throughout the trials. Effects of stocking rate on the livemass gains of the steers were apparent from soon after the start of grazing in each season. At the lightest stocking rate daily gain averaged close to 1 kg $head^{-1}$ d^{-1} over the grazing period. In the two years in which full irrigation was possible, mean gain per steer decreased linearly from 232 and 241 kg at 3.7 steers ha^{-1} to 118 and 113 kg at 14.8 steers ha^{-1}. In these two seasons, calculated maximum gains per hectare were 1 842 and 1 734 kg at stocking rates of 13.3 and 12.3 steers ha^{-1} respectively. In years 3 and 4 (the seasons with reduced irrigation) the maximum gains per hectare were 1 295 kg (at 10.8 steers ha^{-1}) and 964 kg (at 9.9 steers ha^{-1}) respectively. Reduced irrigation therefore resulted in decreased gains per hectare and these were attained at lighter stocking rates. There were marked differences between seasons in the occurrence of bloat, but differences in bloat frequency between stocking rates were not clear-cut.

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An investigation of the sensitivity and power of two monitoring procedures to known levels of vegetation change

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This paper presents an aspect of a study to develop a system for monitoring the grassland of the Wolkberg Wilderness Area, which is situated in the Northern Transvaal of South Africa. The objective of this component of the study was to test through an iterative process of baseline and follow-up surveys, the sensitivity and power of two monitoring procedures to known levels of real and simulated grassland change, under increasing sampling intensity. Sensitivity is described in terms of avoidance of a Type I error, which in a monitoring context means a change is proclaimed when no change exists. Power is described in terms of the ability to avoid Type II errors, which means that no change is declared when a change does in fact exist. The baseline data were collected from a 43.5-ha site using the wheel point apparatus to record the nearest rooted living plant to each of 200 points per 40 m x 40 m plot. Sixty such plots were randomly located. The follow-up survey was executed immediately after the baseline survey, before any change in the vegetation could possibly have occurred. The follow-up data were then artificially changed by 10, 20 and 40% to yield four sets of follow-up data. The baseline and each follow-up set of data, with a known degree of change, were compared through the testing of a null hypothesis (H_0) which stated that there was no significant difference between the two. H_0 was tested through two different analysis procedures, namely a similarity coefficient procedure based on the Sorenson quantitative index and an ordination procedure based on the frequency distribution of samples along the primary ordination axis, using detrended correspondence analysis. To achieve a complete monitoring system that detects change before it becomes serious or far advanced and also facilitates the identification of the nature and cause of change, a wise combination of these two procedures is suggested.

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Animal unit equivalence: towards a new paradigm for rangelands

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Rangelands are commonly used by a mixture of different herbivore species and different classes within species. For comparative purposes, animal unit equivalence is almost universally standardised by means of relations between animal size and energy intake. In this paper we argue that equating animals of different types by means of energy consumption bears no relation to their impact on rangelands, and that the conventional paradigm is, therefore, flawed for the purpose of range management. In particular, we argue that, at equatable levels of energy consumption, small herbivores generally impact the vegetation to a far greater extent than large herbivores. We present three case studies to support our argument, and formulate a conceptual model to explain the difference in impact of grazing by sheep or cattle.

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Optimal nitrogen fertilization strategies for grazed temperate grass/clover pastures

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Recommended optimum nitrogen (N) fertilizer rates, for grazed *Lolium multiflorum* pastures, are currently based on data from cutting trials. In addition, these N-application rates are based on biological and environmental optima, with little attention being given to the calculation of economic optima. In February 1991 a grazing trial was established to address these issues. Varying rates of N fertilizer were applied to an irrigated, sheep-grazed *Lolium multiflorum* cv. Midmar / *Trifolium repens* cv. Ladino pasture. From the data collected, optimal (biological and environmental) N application rates were estimated at 260-280 kg N ha^{-1} a^{-1}

for the *L. multiflorum/T. repens* pasture. Data from previous cutting trials estimated optimal N rates at 350 kg N ha^{-1} a^{-1} for a pure *L. multiflorum* pasture. Economic optimal rates were estimated by three methods. In the first method, profits are maximized when the total value of product (TVP) is maximized above total costs (TC). A second method considers profit directly as a function of input, optimum input occurring where profit is a maximum. The third method involves the comparison of the slopes of the TVP, (value of marginal profit, VMP) and TC (unit price of fertilizer, Px) curves. Profits are maximized when the slope of the VMP and Px are equal. Assuming a typical dairy and beef enterprise on intensive *L. multiflorum/T. repens* pastures in the Midlands of Natal, economic optimum N application rates were estimated (mean of three methods) at 360 kg N^{-1} a^{-1} and 300 kg N^{-1} a^{-1} for the dairy and beef systems respectively. However, by increasing the cost of N fertilizer marginally, these animal production enterprises became unprofitable. As the price of N fertilizer is linked to the fuel price, which on its own could cripple the economics of annual reestablishment, it is imperative that the economic sustainability of each enterprise be investigated. Due the rapid deterioration of soil organic matter status with annual reestablishment, the sustainability of pasture systems, based on annual reestablishment, is questionable. In the current global economic climate, coupled with environmental considerations (i.e. nitrate leaching), more emphasis should be placed on the preservation of soil structure and a reduction in N fertilizer application rates. Future research efforts should be aimed at minimum tillage reestablishment of annual pastures, alternative perennial temperate pastures (e.g. *Lolium perenne* and *Festuca arundinacea*), and the inclusion of a companion legume (e.g. *Trifolium repens*) as a source of N.

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Development of spectral-biomass models for mapping and monitoring montane grassland resources: a preliminary study designed to allow satellite remote sensing of natural resources

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The aim of the study was to assess the feasibility of using satellite imagery for monitoring regional scale, quantitative biomass levels within the montane grasslands of the Drakensberg. All analyses were based on the use of simulated satellite data derived from a boom-mounted field spectroradiometer. The study had three main objectives, firstly to determine the accuracy with which montane grassland biomass (at different growth periods) could be modelled using the spectral vegetation index known as the normalised difference vegetation index (NDVI); secondly, to determine the best seasonal window for annual monitoring using remote sensing techniques; and thirdly, to compare the sensitivities of simulated LANDSAT thematic mapper (TM) and SPOT multispectral (XS) NDVI data to grassland biomass, in terms of operational monitoring. Field spectroradiometer and biomass data for *Themeda*-dominated grassland were collected approximately weekly at the Brotherton burn trials (Cathedral Peak, Natal) throughout the 1991/1992 growing season, for a range of burn treatments. The specific management treatments sampled were: (1) biennial spring cool burn (entering second growth season), (2) annual winter burn (first growth season), (3) no burn (currently 10 years); and (4) eight-year rotational burn (currently in the third year post-burn). Biomass data consisted of measurements of standing live and dead material, clipped from a 0.167-m^2 quadrat, and leaf area index values (LAI) obtained using an LAI-2000 plant canopy analyzer. The correlation between each measured biomass parameter and calculated NDVI value was then determined using a linear regression model. The results showed that the NDVI can be used to predict live green material with a high degree of accuracy, although total and dead biomass could not be predicted for the conditions encountered in this study. The regression analyses calculated between NDVI values and the various biomass components for all treatments were consistently significant for living plant material, varying between $r^2=0.930$ (for the biennial spring burn) and $r^2=0.682$ (for the annual winter burn). A definite seasonal window was evident between the end of October and mid-December, where NDVI values for the burning treatments separated most clearly. Within the seasonal window three distinct NDVI responses were evident, equivalent to one-, two- and three-plus-year veld ages; related to the different biomass levels associated with each treatment. No significant relationships were found between NDVI and LAI, except within the annual winter treatment, where live material constituted approximately 80% of total biomass for all sample dates. A very significant relationship was found to exist between simulated LANDSAT TM and SPOT XS NDVI data throughout the sample period, and for all treatments. It can therefore be concluded that both TM

and XS NDVI data would have the same sensitivity to the specific grassland conditions measured in this experiment.

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Quantitative biomass monitoring and fire severity mapping techniques in savanna environments using LANDSAT Thematic Mapper satellite data

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The ability to provide cost-effective, rapid and quantitative estimates of savanna vegetation biomass will be of direct benefit to a wide range of conservation activities in southern Africa. The primary aim of the study was to: (1) establish quantitative relationships between satellite-derived spectral data and grassland biomass in different seasons; (2) verify the level of fire-scar mapping accuracy that could be achieved using high resolution LANDSAT thematic mapper (TM) data; and (3) quantify, where possible, burn severity. Two LANDSAT TM images were acquired at the beginning and end of the main 1992 winter burn period, on 19 March and 11 September 1992, covering the Hluhluwe-Umfolozi Game Reserve in Zululand. Field data were collected during equivalent time periods to provide quantitative estimates of seasonal biomass for the calibration of both satellite images. A spectral-based vegetation index termed the normalised difference vegetation index (NDVI) was used to derive pre- and post-burn quantitative biomass maps of the reserve. An additional classification of the September imagery was used to successfully delineate actual fire-scar extent. Using a combination of these derived datasets, seasonal changes in available biomass could be determined and accounted for in terms of fire and non-fire related activities. The NDVI was found to be a reliable estimate of total herbaceous biomass for both seasonal periods, with the greatest correlation being recorded for the March/April period when 25-45% of biomass was still green (e.g $R^2=0.76$ for March/April, and $R^2=0.61$ September, all values significant at $P= 0.005$). No significant correlation was found between the NDVI and either non-green woody biomass (> 1 m) (taken as an index of bush-encroachment), or tree biomass (up to a maximum of 45% canopy cover). The results indicate that the canopy cover of savanna woodland is more transparent in terms of remote sensing than actual cover measurements would suggest. The results of the fire-scar mapping exercise were found to be very accurate, and clearly illustrated several advantages in both mapping accuracy and speed over comparable field-estimated map products. Considerable differences were noted for both the total extent of fire-scars, and actual fire boundaries based on field-estimates and the satellite classification. For example, field reports estimate a total of 12 693 ha (or 13.53% of the total reserve), whereas satellite-derived estimates are only 8 441 ha (or 9.0% of the reserve). This represents a difference of 4 252 ha (or 4.5% of the entire reserve). In conclusion therefore, satellite imagery would seem to provide a very effective tool for accurate mapping and monitoring of both total herbaceous biomass and fire-scars in grasslands and open savanna woodland environments.

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Cultural complexity can contribute to ecological and socio-economic resilience in Africa

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Human diversity and ecosystem diversity are interdependent, and are two of the cornerstones of sustainable resource utilization in Africa. People with different value systems have different needs, and therefore utilize and mange the land differently. This leads to a mosaic of landscapes and habitat patches at a regional scale, with a corresponding increase in faunal and floristic species richness. Cultural heterogeneity is also related to economic diversity, because people with different backgrounds traditionally prefer different economic activities. Biological and economic diversity increases the resilience of the entire system. This enables the ecosystem to withstand climatic fluctuations, and enables society to absorb market fluctuations. A 1 300-km^2

section of the Great Fish River valley in the eastern Cape is used to illustrate the relation between cultural diversity and biological diversity. The valley is inhabited by land managers with a wide variety of value systems. This includes nature conservationists, large-scale commercial farmers, small-scale commercial farmers and subsistence pastoralists. Biotic communities were compared across fencelines on five properties which represent the full spectrum of land management practices and value systems. A state-controlled nature reserve was used as a control. Landscape patchiness was measured as the coefficients of variation of pixel values in a satellite image. Plant species were sampled in nested plots and quantified in species-area curves, and arthropods and reptiles were caught in pitfall traps. Landscape patchiness, and plant, arthropod and reptile community composition differed across fencelines. Observed differences in biotic communities could be a result of differences in resource utilization intensities, with the highest species richness at intermediate utilization intensities. The overall diversity of the study area was increased by the variation in land management practices. The diversity of land management styles led to an increase in ecosystem diversity as measured by the β-turnover across property boundaries. We postulate that these differences are caused by a diversity of human value systems. When the diversity of value systems is reduced through anthropogenic catastrophes such as war, famine or unabated population growth, ecological and economic diversity could decline with a subsequent decline in sustainable development. Rural development strategies should aim to maintain a variety of value systems at a regional scale. In conclusion, biodiversity in managed systems is driven by a variety of abiotic, biotic and social factors which are often interlinked. The traditional scientific methods of testing hypotheses to solve range management problems might not be appropriate when dealing with such complex systems.

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Production and physiological responses of Italian ryegrass (*Lolium multiflorum* cv. Midmar) and white clover (*Trifolium repens* cv. Ladino) grown in monocultures and mixed stands

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The aim of this study was to test the hypothesis that ryegrass and clover, when grown under optimal conditions in mixed stands, interact in response to available light energy. With other resources non-limiting, pasture yield is determined by the efficiency with which solar radiation is intercepted by foliage and converted into dry matter. The clover-ryegrass interaction under varying light regimes, as experienced in the canopies of these pastures, was studied by investigating the growth and production of ryegrass and clover in relation to light harvesting abilities and photosynthetic utilization of intercepted light. Pasture canopy structure and growth were studied under a four-weekly clipping treatment. The interception of photon flux density (PFD) in the pasture canopy was monitored diurnally and seasonally in mixed and mono cultures. Light use efficiency (CO_2 fixed/ unit absorbed PFD) as well as photochemical efficiency of photosystem II (F_v/F_m) were studied by monitoring CO_2 assimilation rates and chlorophyll fluorescence respectively. The results obtained from this study indicated that interaction did occur between ryegrass and clover cultivated in mixed pastures. The mixture was capable of more efficient light interception than the monocultures, which resulted in higher productivity. Light interception abilities, as manifested in canopy architecture, and not physiological utilization of light energy, were found to govern the interaction between the two pasture components.

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Wildlife production systems in South Africa : are they delivering the goods?

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Within southern Africa there has been an upsurge in the commercial exploitation of wildlife on private and communal land. Even within formally conserved parks and reserves a swing towards the 'if it pays, it stays'

approach is noticeable. Early proponents of wildlife production systems speculated over the comparative advantages of indigenous multi-species systems versus single- or two-species domestic livestock systems. In Zimbabwe the CAMPFIRE programme plus, in some circumstances the commercial ranching of game, are held as examples of this comparative advantage. In Botswana theoretical models predict such a comparative advantage. However it is in South Africa where this from of landuse is most widely practised and where, paradoxically, the least amount of quantitative data are available, particularly regarding the financial and economic aspects. Those data that do exist either illustrate the same low order of return as derived from extensive cattle ranching, or indeed the financial superiority of cattle ranching. In terms of the private commercial sector, the question arises as to why this form of landuse is increasing in South Africa. If it is neither unequivocal biological or financial superiority then we ask the question, what is it? It could be that commercial livestock ranching has become increasingly unattractive and that wildlife ranching is perceived to be a better substitute. It has further been suggested that investment in land *per se*, tax considerations, and lifestyle rate high in the decision process. We do not subscribe to this view as being generally applicable, given the billions of Rands being invested on which surely some return is expected. We feel that inflated expectations fuelled by past exorbitant prices for live game and the perceived promise of foreign exchange through trophy hunting and ecotourism have partly contributed to the recent growth in the industry. As far as communal areas are concerned, South Africa differs from the CAMPFIRE model in that the wildlife areas are smaller, do not have valuable game species and have much higher human and domestic stock numbers. Many of these enterprises are not profitable unless one-off injections of donor capital are used to kick start the project. In this paper we explore some of the conditions that need to be met for an enterprise to be financially and economically profitable in both the private and the communal commercial sectors in South Africa.

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The potential of *Digitaria eriantha* as foggage in the Highland Sourveld of Natal

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The production of forage for over-wintering livestock is an important component of livestock production in Highland Sourveld. Traditionally, hay, silage and crop residues have been used to maintain animals, such as dry cows and weaners, during winter. An alternative is to produce foggage. *Digitaria eriantha* is adapted to a wide range of climatic and soil conditions. One of its reported major attributes is that it maintains its quality when mature. It is therefore widely recommended for use as foggage. A cutting trial was designed to examine the effects of closing date (viz. mid-December, beginning-January, end-January and late-February) and nitrogen application rate (viz. 0, 100, 200, 300 and 400 kg N ha^{-1} a^{-1}) on the quantity (kg DM ha^{-1}) and quality (% crude protein (CP) and % non-structural carbohydrates (CHO)) of *D. eriantha* foggage during winter (July). The trial was conducted at Kokstad (30°31'S, 29°25'E; altitude of 1 341 m a.s.l., mean annual rainfall of 780 mm). Four season's data were analyzed. The amount of foggage produced increased with increased nitrogen application rate to 200 kg N ha^{-1}. There were no significant differences (P=0.05) in production between the 200, 300 and 400 kg N ha^{-1} application rates for any of the closing dates. Maximum foggage production (4 500 kg DM ha^{-1} to 8 000 kg DM ha^{-1}) was obtained from the mid-December closing date. Closing the pasture in early-January produced between 2 500 and 6 000 kg DM ha^{-1}. Production from the late-January closing date varied from 500 to 5 000 kg DM ha^{-1} while the late-February closing date produced less than 1 000 kg DM ha^{-1} in all four seasons. The timing and amount of rainfall appears to be a major factor influencing seasonal foggage production in the first three closing dates. Low foggage production from the late-February closing date was recorded in spite of seasonal rainfall pattern. Foggage production from the zero nitrogen application treatments was less than 1 000 kg DM ha^{-1} for all seasons except the first where between 2 500 and 4 000 kg DM ha^{-1} was produced for the first three closing date treatments. These data suggest that there was a large amount of mineralised nitrogen available to the plants in the first season. Leaf to stem ratios were determined for all treatments. Closing date and nitrogen application rates had little influence on the proportion (by mass) of leaf in the foggage except where the treatment resulted in low foggage production (i.e. at zero nitrogen and the last closing date). Leaf comprised approximately 85% to 100% of the herbage in low foggage production treatments. For all other treatments the proportion of leaf ranged between 67% and 75%

with a general, non-significant trend of decreasing proportion of leaf with increasing nitrogen application rate. Crude protein content of the leaf ranged between 3 and 12%, increasing with increased levels of nitrogen application and later closing dates. The same trends were recorded for the stems. However, CP of stems was below 4% in all treatments. Mean CHO levels of the stems (8.5%) was higher than that recorded in the leaves (5%) with very little difference within leaves and stems due to the treatments applied.

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Grazing capacity and the large stock unit equivalent: are they compatible?

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The paper aims to provide a basis for discussion regarding the use of large stock unit equivalents (LSU) when applying terms such as grazing capacity, carrying capacity and stocking rate in livestock production systems. The main issue involves highlighting the potential problems/misunderstandings which arise when using the LSU to characterise the livestock production potential of, and grazing impact on, an area of veld or pasture. An inherent assumption in characterising the carrying capacity (LSU ha^{-1}) of a pasture at maximum livemass gain per hectare, for example, is that the number of LSU ha^{-1} would be the same for any class or species of animal. Another assumption is that the replacement of one animal species (e.g. cattle) with the equivalent number of LSU of another species (e.g. sheep), would result in the same grazing impact as would have occurred had the former species not been replaced, hence the determination and use of grazing capacity "norms" for all veld types in South Africa. Animal performance and grazing impact data are presented in discussing the merits of these two assumptions. Jones and Sandland models were developed to compare the animal production potential of kikuyu pastures when grazed by either 14-month-old or 26-month-old steers. Mean seasonal average daily gains (ADG in kg $animal^{-1}$) were calculated and related to stocking rate (expressed as the mean number of LSU ha^{-1} per treatment for the grazing season). The results clearly indicate that the performance of the younger steers was superior to that of the older steers in all cases where both groups of animals were stocked at the same number of LSU ha^{-1}. A similar approach was used to compare the maximum expected gain per hectare from kikuyu pastures when grazed either by sheep or by cattle. Again, the results clearly indicate that the number of LSU ha^{-1} for maximum livemass gain per hectare in the sheep production system differed markedly from the cattle production system. We also compared the impact of grazing on sourveld due to various cattle to sheep ratio treatments (each ratio treatment was stocked at the same number of LSU ha^{-1} at the start of the grazing season). Grazing impact was quantified in terms of (1) changes in the number of LSU ha^{-1} through the grazing season (for both cattle and sheep), and (2) patch development, intensity of grazing on individual species and residual herbage mass. Results of these analyses show that the grazing impact of 1 LSU cattle cannot be equated to the impact of 1 LSU sheep. We conclude that defining stocking rate, grazing capacity and carrying capacity in terms of LSU is misleading. We suggest that the use of these terms has resulted in (1) misinterpretation of grazing capacity recommendations, (2) false expectations of animal production potential of veld and pasture by advisors and graziers, and (3) in the worst cases, has contributed to the continued deterioration of natural resources.

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Range condition in relation to winter versus autumn burning

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Autumn, or late summer, burning is commonly applied in the sheep farming areas of northern Natal. The practice of autumn burning and its associated grazing/resting management are perceived to be detrimental to range condition and, therefore, the long-term carrying capacity of the range. Winter burning of herbage carried over from the previous growing season's production is generally recommended for high rainfall grasslands. Together with appropriate grazing management, late-winter burning is thought to ensure

maintenance, or improvement, of range condition and the potential of the range to carry livestock. In this paper we report on an investigation into the effect of winter versus autumn burning, and their associated grazing management, on the relative abundance of grass species, range condition and potential carrying capacity. The study was conducted in the Highland Sourveld of north-eastern Natal and confined (largely) to slopes with a northerly aspect. Three categories of (long-term) past burning practice were identified on farms within the study area, viz. late-winter burning (winter burn), late-summer/autumn burning (autumn burn) and traditional autumn burning which, for at least the past twenty years had been burnt in late winter (autumn/winter burn). Plant species composition assessments were conducted on 102 sample sites which were located across all categories. Additional environmental data (aspect, soil series, soil depth, elevation, moisture status and rockiness) were collected at each site. The effects of past burning practice on species composition were examined using ordination and classification procedures. The weighted key species method of range condition assessment was applied to determine the effects of past burning practice on range condition. Both the ordination and the classification procedures indicated that species composition was strongly correlated to past burning (and associated grazing) practices. The species composition of the autumn/winter burn sites tended to have greater similarity to the winter burn sites than to the autumn burn sites. Autumn burn sites were dominated by Increaser I species whilst the winter burn sites were dominated by Decreaser and Increaser II species. These data reflect, respectively, the long rest periods associated with autumn burning, and the lack of rest and heavy grazing normally associated with winter burning. The additional environmental variables measured for each sample site did not appear to influence species composition of the sites. A comparison of the range condition indices calculated for each sample site suggested that, in general, the autumn burn sites were in better condition than the winter burn sites. In terms of species composition then, this result refutes the general perception that autumn burning results in extreme degradation of the veld.

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Costing range degradation

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Although climatic and market uncertainties present complex management problems for livestock producers, the major decision affecting the level of livestock production is stocking rate. The stocking strategy selected by the land-manager may have a major impact on short-term profitability, while in the long term may influence the resource-base. Stocking strategy decisions made by land-users must satisfy both economic and biological objectives to ensure sustained livestock production. Neglecting either implies that the system will ultimately fail. While the consequences of range degradation through grazing have been well documented, confusion arises where vegetation change as a consequence of grazing is described as overgrazing. Changes through grazing may not be detrimental, particularly where livestock production remains unchanged. In addition, perceptions of overgrazing may be value-based and depend on user objectives, while optimum range condition may change from season to season and with management objectives. While part of the costs of overgrazing are internalised and borne by the range-user in the form of reduced financial returns, other costs are less obvious and are external to the system. These may include costs of dam and estuary reclamation through siltation. It may be argued that as conservation farming fails to maximise benefits in the short-term, graziers are tempted to profit at the expense of sustained production. The value of a resource is, however, dependent on expected future net returns and therefore investment in conservation measures, which increase future expected returns, will increase the value of the resource. There are, however, conceptually two rates which may be used to evaluate resource management decisions, viz. opportunity cost or the social rate of time preference (SRTP). The SRTP is simply the value people place on present consumption over future consumption, although this may depend largely on socio-economic circumstances. This has major implications for resource management decisions made by range-users under subsistence conditions. Despite evidence that conservative stocking yields greater financial returns than higher levels of stocking, range-users continue to apply stocking levels which lead to range degradation and reduced financial returns. Overgrazing is, however, a rational decision in an uncertain environment with high discount rates and strong market distortions created

by government interventions, and where the costs of resource degradation are largely externalised and borne by society. An increase in the SRTP which graziers apply to range management decision-making may encourage optimistic stocking or over-stocking. An integration of ecological, economic and social components of the system may be required to address the challenge of range degradation through overgrazing.

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A preliminary study into the fate of $^{15}NH_4NO_3$-labelled fertiliser on a dryland kikuyu field trial in Natal

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Aspects of ^{15}N-labelled fertiliser recovery were studied in herbage, root and soil components of a dryland *Pennisetum clandestinum* (kikuyu) sward. Four plots, each encircled by open-ended cylinders, which lowered the potential for lateral N movement, received three equal applications of fertiliser N at rates equivalent to 75 kg N ha^{-1}. The first application (October) was singly labelled $^{15}NH_4NO_3$, and the second and third were unlabelled. Herbage and roots were harvested, and soil was sampled at three depth classes (0-300 mm, 300-600 mm and 600-1 000 mm) on six, monthly occasions until March, with the first harvest (October) being used merely as a control to establish the abundance of naturally occurring ^{15}N in each component. The trial ran for one growing season (i.e. October to March) and animals were excluded from the plots by means of exclusion cages. Herbage was dried in a convection oven at 70°C (24 hours), and roots extracted from the air-dried soil after sieving. Composite samples for each component were then analyzed using a mass spectrometer. On average, 56.74% of the NH_4-^{15}N applied was recovered in the herbage over the season, with 40.01% being recovered during November and December. The amount taken up by the plants subsequently declined (significantly ($P < 0.01$) in some cases) in a curvi-linear fashion over time. The highest amount of NH_4-^{15}N recovered in the roots was in December (3.58% of that applied). This was significantly ($P < 0.01$) more than was recovered in November and March ($P < 0.01$) and February ($P < 0.05$). The largest soil NH_4-^{15}N concentration was found in the 0-300 mm depth class. The amount of NH_4-^{15}N recovered within each month declined, on average, from 69.45% of that applied in November to 36.36% in March. The highest amount of NH_4-^{15}N recovered in the 300-600 mm depth class was 10.64% of that applied, in December. In general, NH_4-^{15}N recovery, as a percentage of that applied, declined each month thereafter in this depth class to a minimum in March of 3.28%. A weighted average of the NH_4-^{15}N recovered in the 600-1 000 mm depth class revealed that the least NH_4-^{15}N was found in this depth class at all times during the season. Notwithstanding this, the highest amount of NH_4-^{15}N recovered was in January (4.82% of that applied), this being significantly ($P < 0.05$) more than was recovered in March (1.52%). Unlike the two depth classes above, no distinct pattern in the decline of recovered NH_4-^{15}N was observed from the beginning to the end of the season. However, a slight decline in February and March suggests that some of the NH_4-^{15}N was leaching downwards out of the system. The total amount of NH_4-^{15}N recovered, on average, in the three components over the season was 98.06% of that applied as labelled fertiliser N.

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Goats alone as alternative to cattle and goats for the utilization of semi-arid savanna

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Goat ewes were run on an open to sparse and medium-dense *Acacia karroo* dominated savanna for four years at the recommended stocking rate of 0.141 LSU ha^{-1}. Animal performance was compared to a control stocked at the same rate with cattle and goats respectively at 0.0602 and 0.0806 LSU ha^{-1}. In both the control and the treatments, one-third of the area was rested annually in rotation from July to June while the animals were rotated through the paddocks on the remaining two-thirds of the area. Stocking goats alone was detrimental to the tree component but did not affect the grass component. Tree densities declined by up to 40% over the

four years, while no species composition change was detected in the *Digitaria eriantha* and *Sporobolus fimbriatus* dominated grass component. The average ewe mass on the treatments declined by up to 14% but conception rates, kidding and weaning percentages, and kid growth rates were not significantly affected. Forcing goats to predominantly graze (grass) rather than browse (trees) did not significantly affect animal performance. Goats alone produced on average 10-67% more live mass per hectare than a combined cattle/goat system and were economically more efficient than a cattle/goat system.

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The effect of tree density on the growth and productivity of *Acacia karroo* in south-eastern Africa

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Twig growth and leaf standing crop were monitored monthly over three seasons at four tree densities at two sites in the Stutterheim district in the Eastern Province Thornveld, and two sites in the False Thornveld of the eastern Cape at Adelaide. Individual plot size was 1 ha. Tree densities ranged from 400 trees ha^{-1} up to 2 300 trees ha^{-1}, or 2 000 tree equivalents ha^{-1} (TE ha^{-1}) to 20 000 TE ha^{-1} respectively. The grass cover and composition differed between sites but was uniform across tree densities within a site. Leaf and twig growth was highly correlated with rainfall. Initial twig growth rates were negatively correlated with tree density and commenced up to two weeks earlier at the low compared to the high densities. Although leaf density and leaf biomass varied between sites, no differences in leaf density could be detected within any one site. Browse production per hectare (twig and leaf growth) increased linearly with tree density. Browse production per tree remained constant at low and moderate densities, but was suppressed at high tree densities, showing a significant competitive effect between trees. Empirical relations to predict browse production as a function of tree density and rainfall are presented for the respective sites.

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Modelling growth of *Digitaria eriantha* at various soil nitrogen levels

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The PUTU 14 model was developed to simulate daily dry matter production for *Digitaria eriantha*. In doing so the PUTU 13 model was calibrated and validated, not only to simulate dry matter gain under optimal conditions, but limitations such as nitrogen application were taken into account. A nitrogen balance model was successfully adopted and tested in the PUTU 14 model (r^2=0.98, D=0.97 and r^2=0.99, D=0.99 for 1978/1979 and 1979/1980 growth seasons respectively). Further validation on the 1981/1982, 1982/1983 and 1983/1984 season on an Avalon and Valsriver soil showed good agreement between measured and simulated yield. Five rainfall scenarios were established and applied to the PUTU 14 model. Nitrogen was applied to set limits for each of these scenarios. Indications are that for a bad, poor, moderate, good and wet year, applications of 20, 60, 100, 140 and 240 kg ha^{-1} were adequate for a total yield of 1 000, 2 000, 3 000, 4 500 and 7 000 kg ha^{-1} a^{-1} respectively. The most favourable time of application was found to be 1 November. Furthermore, use was made of the expected yield-variance space from which it was found that a risk averse entrepreneur would prefer a nitrogen application of 60 kg ha^{-1} for Potchefstroom.

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Evaluation of fire as a form of disturbance in southern Africa savannas

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Fire is an important factor in the maintenance of savannas in many parts of the world, including southern Africa. Natural fires are considered an integral part of savanna systems, and fire has been widely used to manage the vegetation in these ecosystems. Much of the burning philosophy, however, has been based on dogma, which has strongly influenced recommendations on the use of fire for the management of both woody plants and grasses. In this paper I assess the potential of the current burning dogma in the light of several savanna management scenarios, and then consider alternative burning strategies and regimes. Regular burning is required for the manipulation of the woody component in savanna cattle production systems. The objective of burning here is to remove as much competition from the woody layer as possible in order to maximize grass production. This management system is not economically sustainable as the fuel is usually potential fodder. Fire management in these systems needs to be based on a philosophy where the long-term management of the vegetation is the primary objective, and other forms of utilization of the woody plants is introduced to complement the effects of fire. Theoretically the use of fire during midsummer droughts will have a greater effect on the long-term dynamics of the woody plants than dormant-season fires. The rationale behind this form of management is outlined, and recommendations for future research are proposed.

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An integrated approach to bush control in southern Africa

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Bush encroachment poses a major problem to the management of savannas globally, particularly where management objectives tend towards grazer production or ecotourism. In this paper we review the bush encroachment process in terms of a successional gradient and the associated natural disturbance regimes. We assess options available to management in order to maintain the vegetation at a particular state along this gradient and make comparisons between natural and applied disturbances. We stress the importance of land-use management objectives in a bush control programme, and provide a broad model for managing woody plants in southern African savannas under different forms of management.

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The influence of bush clumps on the soil properties, microclimate, herbaceous composition and production in an eastern Cape savanna

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The vegetation of the study area consists of a clumped, multi-species, woody component in a grassland matrix. This paper addresses the effect of bushclumps on the environment and on the herbaceous component. The soils of the bushclumps and adjacent grasslands were examined. The fertility status of the grassland soils was poorer than the bushclump soils. Concentrations of organic matter, N, P, K, Mg and Ca were significantly higher under bushclumps than in the adjacent grasslands. Sodium was higher in the grasslands soils than in the bushclumps soils. Bulk density of topsoils but not subsoils was lower under bushclumps than under grasslands. Cation exchange capacity and infiltration rate were significantly higher in the A-horizon under the bushclumps than in the open, and decreased with depth. Results suggest that the clumps function to improve soil conditions under them by re-distributing nutrients from areas beyond the clump to beneath the clump. Preliminary

investigations indicate that the roots of *Scutia myrtina*, one of the main constituents, extend up to 20 metres into the adjacent grassland. The herbaceous flora associated with the clumps was sparse and characterized by species such as *Helictotrichon capense*, *Stachys aethiopica* and sedges; grassland species such as *Themeda triandra*, *Sporobolus africanus*, *Cynodon dactylon*, *Aristida congesta*, *Digitaria eriantha*, *Eragrostis chloromelas*, *Chaetacanthus setig* and *Selago corymbosa* were generally absent and so were their seedbanks. The periphery of the bushclumps is characterized by grassland species such as *Eragrostis curvula* and *Teucrium trifidum*, and canopy-related species such as *Panicum maximum* and *Pentanisia prunelloides*. Functions for the relationship of herbaceous production with distance from bushclump are described. In contrast to the grassland regions, bushclumps had a moderating effect on temperature and humidity.. Temperatures in the grassland were generally higher during the day and lower at night. Humidity during the day was 5 to 10% lower in the grassland than in the bushclumps. Compared to open grassland, bushclumps reduced solar irradiance by 80-95%. The implications of these findings for an understanding of bush-grass interactions, and the encroachment of clumps into grassland, are discussed.

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Towards improved grazing management recommendations for sourveld

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Critical evaluation of grazing management recommendations for sourveld revealed scientific, economic and practical deficiencies. These recommendations are seldom adopted. Recent scientific evidence has facilitated the adoption of certain principles in new practical, economically viable recommendations aimed at maintaining or improving the resource while facilitating good animal performance. These are based on the principles that defoliation, particularly by sheep, is detrimental to the vigour of the preferred species and that extended rests are necessary as compensation. Recommendations are aimed at optimal utilisation of veld burnt in spring after a full growing season rest. This is followed by compensatory rests every alternate year with sheep alone or use by cattle for one or two years depending on sheep:cattle ratios, followed by a full season rest. Rested veld utilised during the dormant season is an important feed source.

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Natural vegetation mapping and monitoring by means of Landsat-TM satellite data

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The aim of the study was to determine the potential and level of detail that can be achieved in identification of natural vegetation with the use of digital Landsat-TM satellite data. A part of the study was undertaken in a grassland area of South Africa (central Orange Free State). Aspects investigated included the identification and separation of veld condition classes (mainly based on species composition) as well as biomass differences within different veld condition classes. Another facet of the study concentrated on the discrimination between bush-encroached and debushed areas at farm level in the Grootfontein-Otavi area in Namibia. A 96% identification accuracy was obtained in this part of the study. Furthermore the use of multi-temporal imagery is also being investigated.

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Centrosema pubescens (centro) and *Manihot esculenta* (cassava) intercropping: the effect of spacing and time of planting centro on seed yield

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The effect of time of inter-planting centro (*Centrosema pubescens*) with cassava (*Manihot esculenta*), at various spacings, on the seed yield components of centro was investigated. Centro is a climbing legume that requires some form of support to maximize seed yield and cassava is widely grown in Uganda. Its erect stems can provide necessary support for the seed production of centro. When planted in monoculture at the recommended spacing of 1 m x 1 m, cassava may be too close for an intercropping system. Cassava cuttings 150 mm long were planted at a spacing of 1 m between the plants, and at inter-row spacings of 1.5 and 2 m. Centro seeds were planted close to cassava at the same time, two and four months after planting cassava. The trial design was a randomized complete block design in split plots. Time of planting centro was in the main plots while cassava spacing was in the subplots. Seedlings of centro were thinned to one per cassava plant during weeding. Days to first flowering, flowers per inflorescence, pods per seedhead, seeds per pod and weight of 100 seeds were recorded. Mature pods were harvested by hand at fortnightly intervals. Centro planted at the same time as cassava flowered within 138 days, irrespective of cassava spacing. The seedlings twined on cassava stems as they developed. The speed of growth of centro planted after cassava seems to have been suppressed by shade and competition from relatively older cassava plants, resulting in flowering after 180 days for all the spacings. There were no differences among seed yield components for the three times of planting centro relative to cassava. Strong negative associations between total seed yield and time of planting were observed for all the cassava inter-row spacings. This was ascribed to poor legume establishment as a result of competition with old cassava plants and shorter harvesting periods of late planted centro. Average seed yield from centro planted at the same time as cassava, two and four months later was 785, 326 and 110 kg ha^{-1}, respectively. Cassava-inter-row spacing had no effect on most of the seed yield components. Negative associations between total seed yield and inter-row spacing at all the planting dates were observed. This was attributed to a reduction in the number of centro plants and a reduced support surface area from a lower cassava plant population. Average seed yield of centro growing with cassava at an inter-row spacing of 1, 1.5 and 2 m was 517, 399 and 311 kg ha^{-1} respectively. Seed yield (982 kg ha^{-1}) of centro was maximized when the legume was planted at the same time with cassava spaced at 1 x 1 m.

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The management of communal grazing lands

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The main objective of proper range management is to achieve sustained livestock production through increased rangeland production. Livestock play a central role in the economic and social welfare of rural inhabitants throughout the African continent in terms of animal draught power, milk, manure for maintenance of soil fertility, meat, cash and satisfaction of cultural needs. However, the overall impact of grazing animals is to influence some combination of vegetation and soil characteristics. Overgrazing for extended periods results in vegetation changes; mainly an increase in undesirable species and a decrease in desirable species. This leads to reduction of protective cover, increasing the erosivity of raindrops and surface runoff, decreasing infiltration rates, increasing erosion, increasing surface crusting, lowering of soil organic matter and decreasing soil aggregation. The end result of extended periods of overgrazing is a lowering of the potential production of an area and overall degradation. Overgrazing in most communal areas in Africa is a result of overstocking and mismanagement. In Zimbabwe, for example, communal cattle, sheep, goats and donkey populations have been increasing substantially over the past 20 years. This has resulted in damage to rangelands to the extent that over 50% of the total grazing areas in communal lands have been estimated to be either bare or very overgrazed for most of the year. In order to rectify the deteriorating situation in these areas, comprehensive grazing schemes have been found to be a necessary intervention which improves livestock production in the

communal areas and helps to conserve vegetation cover on rangelands. These systems include rest, reasonable stocking, increased offtake, flexible management, land improvement and constantly monitoring for the symptoms of degradation. For success, any grazing management scheme must be locally specific, taking into consideration critical constraints, availability of forage, the browse resource and the objectives and management abilities of local communities. Where the grazing has been denuded and the cover is very low, specific reclamation measures were found to be necessary. These methods include spot/strip seeding, contour furrowing, pitting and gully treatment measures. It must be emphasised that preventing the formation of a gully in the veld is much easier than controlling it once it has formed. In the high rainfall areas, it was realised that emphasis should be put on intensive cropping schemes which incorporate provision for production of livestock feed from crop residues, short- and long-term leys, planting of legumes and fodder trees. Finally, wholesale recommendations for improving rangelands in the communal areas can have negative effects and can end up with disastrous results. Farmer training and absolute involvement right from the start of the grazing management scheme is essential.

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Potential of the alkane technique for estimating dry matter intake and species composition of intake: a review

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The accurate estimation of forage intake and species selection by the grazing animal is a serious problem confronting pasture and animal scientists. However, the recently developed n-alkane procedure appears to give reliable estimates of both dry matter intake and species composition of the ingested herbage. The procedure is described and its advantages and limitations in pasture and animal nutrition research are reviewed.

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Using the growth response of a floodplain grass (*Oryza longistaminata*) in the formulation of management strategies with regard to a changing hydrological regime

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An increasing urban water demand in the Nylstroom region of the central Transvaal, South Africa, has resulted in the proposed construction of a dam upstream of the Nyl river floodplain. This threatens to alter the natural hydrological regime and therefore affect the ecological functioning of this 24 000 ha floodplain vlei. In order to try and predict the ecological consequences of any water management options, information on how the nature and dynamics of the water supply to the floodplain affects the biota was required. To address this issue, a research programme was initiated aimed at generating information which could be used in the formulation of a management plan with regard to the ecological water requirements of the floodplain. A key study in this programme focuses on the response of the dominant floodplain grass, the wild rice *Oryza longistaminata*, to different hydrological scenarios. The wild rice is a perennial rhizomatous hydrophyte which proliferates and dominates most of the inundated areas of the floodplain shortly after the arrival of a flood. It provides grazing for domestic and wild animals as well as an extensive breeding and feeding habitat for many of the floodplain fauna during this time. The carbon allocation patterns and above- and below-ground growth of *O. longistaminata* were measured in response to two components of the hydrological regime, the depth and duration of flooding. The construction of flooding tanks enabled accurate control of water level fluctuations and three flooding depths and durations were simulated (250, 500 and 750 mm and 25, 50 and 135 days respectively). Carbon allocation patterns changed in response to different depths of water, while net productivity varied with different durations of flooding. In combination, changes in the depth and duration of flooding result in changes in the life-history response of *O. longistaminata*, providing information about the water requirements of this dominant floodplain grass species. Information generated by this type of study can be used in the formulation

the usefulness of including an autecological approach when trying to determine the water needs of natural wetlands threatened by over exploitation, an ever increasing challenge in wetlands of semi-arid developing areas.

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Development of a range monitoring technique for the False Thornveld of the eastern Cape

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Multivariate procedures were used to rank species along inferred grazing gradients in six range types identified in the False Thornveld of the eastern Cape. On the basis of these rankings, three methods of monitoring changes in species composition were developed. The first was a detrended correspondence analysis (DCA) weighted species method using all species along the inferred grazing gradients. The second method was a DCA weighted species method using only those species which exhibited a response along the grazing gradients, and the third used stepwise multiple regression between the axes representing the grazing gradient, and the relative abundance of species along the gradient. These three methods of monitoring change, together with methods currently used in the False Thornveld, were compared with DCA ranking of independent sites chosen to represent the grazing gradient within each range type. The stepwise multiple regression method was in all cases more strongly correlated to the DCA ranking of sample sites than the other methods used in the evaluation. It is proposed that this method be used to monitor changes in the False Thornveld.

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Herbage dry matter production and quality of *Lolium perenne* L. as influenced by grazing management in Natal

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A trial was established in September 1992 on the University of Natal's research farm Ukulinga to examine the impact of sheep on the yield and quality of *Lolium perenne* (perennial ryegrass). All treatments received equal fertilizer (40 kg N ha^{-1} per month) and irrigation (25 mm per week). Six grazing management systems were compared in terms of herbage dry matter (DM) production and herbage quality. These included various combinations of grazing frequency (HF, MF and LF = high, medium and low frequency, respectively) and grazing intensity (HI, MI and LI = high, medium and low intensity, respectively), applied as rotational grazing. A continuous grazing system (CG) was also applied. Each of these treatments was replicated four times in a randomized blocks design. Based on long-term temperature data for Ukulinga, seasons were divided as follows: summer (October to March), autumn (April and May), winter (June and July), and spring (August and September). Herbage DM production was estimated using a pasture disc meter and data were subjected to analysis of variance. Summer production ranged from 7 316 (CG) to 8 511 kg DM ha^{-1} (LFHI). LFHI significantly outyielded HFLI and CG, while HFLI significantly outyielded CG ($P<0.05$). Autumn production ranged from 3 637 (HFHI) to 5 161 kg DM ha^{-1} (HFLI). LFHI significantly outyielded MFMI, LFLI and HFLI while both HFHI and CG were significantly outyielded by MFMI, LFLI and HFLI ($P<0.01$). Winter production ranged from 2 463 (LFLI) to 3 574 kg DM ha^{-1} (HFLI). Apart from the low yield of LFLI (2 463 kg DM ha^{-1}), treatments incorporating intense defoliation and continuous grazing were outyielded by those incorporating medium and lenient defoliation ($P<0.05$). Spring production ranged from 2 857 (HFHI) to 3 863 kg DM ha^{-1} (LFLI). HFHI was significantly outyielded by MFMI, LFLI and HFLI ($P<0.05$). Production for the full first year (October 1992 to September 1993 inclusive) ranged from 17 235 (HFHI) to 19 820 kg DM ha^{-1} (LFLI). HFHI was significantly outyielded by MFMI, LFLI and HFLI. The DM production data serve to illustrate that, generally, higher yields are attainable from low frequency, low intensity defoliations than from high frequency, high intensity defoliations. There were no significant ($P>0.05$)

treatment effects on digestibility (% of DM disappearance) and nitrogen (N) content (% N on DM basis) of the herbage. There was, however, a seasonal trend where both digestibility and herbage N content dropped from 75 % and 4.5 %, respectively (in winter, spring and early summer) to 55 % and 3.2 %, respectively (during late summer and autumn). The herbage quality data illustrate that, for perennial ryegrass, the manner in which the pasture is utilized does not appear to effect its quality.

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Use of multivariate techniques to monitor vegetation change in the Arid Karoo

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The development of veld management strategies requires a knowledge of veld condition, vegetation dynamics and grazing capacity. To ensure optimal utilization of veld, it is essential to quantify the condition of the veld. The ecological index method was developed to evaluate veld condition in the Karoo. Similar techniques have been developed in other biomes. Recent developments in other biomes concentrated on improving existing techniques. No similar developments have been reported for the Karoo. Foran and co-workers have developed a procedure for vegetation monitoring in arid rangeland, using multivariate techniques. This procedure was successfully used in the determination of veld condition trend in the semi-arid savannas of the eastern Cape and the climatic climax grasslands of South Africa. This paper examines the suitability of applying these procedures for the detection of trend in veld condition in the Arid Karoo. This was done by analysing vegetation data collected in a long-term grazing capacity trial, where the veld is stocked at four stocking rates. Monitoring transects were permanently demarcated in all plots during 1988. Percentage canopy spread cover and botanical composition were used as basis for the description of the vegetation. Data were gathered in the autumn of 1988 and 1991, using the descending point method. One-thousand points per plot were recorded. In the absence of a canopy spread cover strike, nearest plant data were recorded to determine botanical composition. The data were analyzed using the ISPD program. This software provides access to three well-known multivariate ordination procedures. An ordination procedure, developed to analyze data from reasonably homogeneous areas, was also used to analyze the data. The TWINSPAN classification and DECORANA ordination of both data sets stressed the temporal variability of karoo vegetation and the importance of interpreting classification and ordination results with due cognisance being taken of environmental and managerial data. The ordination of vegetation data within reasonably homogeneous areas, in order to identify degradation gradients (DMOC ordination), presented problems. The effect of a (dominant) species, which is fairly insensitive to grazing, prevented the identification of a degradation gradient. Similar problems may be encountered elsewhere where similar conditions prevail. Ordination of the canopy spread cover data, by means of the DMOC model, was better related to veld condition trends than the ordination of botanical composition data. This differs from grassveld areas, where nearest plant (frequency) data are used in ordinations to quantify changes in veld condition. It indicates that the same type of data used to calculate veld condition should be used in ordinations for the purpose of vegetation monitoring.

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Keystone species: is function is modified by demography?

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Key species are those on which many other plant and animal species depend. Key species may create heterogeneity, prevent single species dominance or supply a critically limiting resource. We maintain that the functions performed by a key species may be modified by its population structure, density and distribution. As an illustration of this principle, we show that the 'goods and services' provided by large trees differ

considerably from those provided by saplings of the same species. Our data were gathered during a study of *Acacia erioloba* in the Kalahari Gemsbok National Park, during which we recorded the perennial plant composition beneath 128 *A. erioloba* saplings, 154 live and 69 dead *A. erioloba* trees and in 131 treeless plots. The nutrient status of soils was sampled under live and dead trees and in the open. Large *A erioloba* trees scattered through the low and sparse vegetation of arid oligotrophic savannas are focal points for animal activity. Mammals (gemsbok, springbok, lion, bat-eared fox, jackal) were frequently observed in the shade of large trees during the heat of the day, and their dung was concentrated beneath the trees. Large trees were used as nest and roost sites by a greater variety of bird species than were small trees. Only large trees are capable of supporting the massive nests of sociable weavers. Vultures and raptors generally perched on large trees and senescent trees provided natural cavities suitable as nest sites for birds and small mammals. Over the decades, fallen nest material and the faeces of birds together with mammalian carcasses and faeces enrich the soil beneath large trees. Beneath live *A. erioloba* trees, nitrogen levels were 200-500% and the phosphorus levels 150-250% greater than on intervening sand plains. Soils beneath dead trees had intermediate nutrient levels. Plant species with seeds that are dispersed in bird and mammal faeces (*Lycium*, *Grewia*, *Boscia*, *Solanum*, *Galenia*), were present beneath all large *A. erioloba* trees sampled, but only occurred in 31% of samples beneath *A. erioloba* saplings and in 10% of treeless samples. Similarly, plants with seeds dispersed on the pelage of mammals (*Setaria verticillata*, *Tribulus terrestris*) appeared more abundant beneath large trees than in the open. Large *Acacia* trees in arid oligotrophic savanna are shelter sites for birds and mammals and facilitators of palatable grasses and fruiting shrubs. We suggest that *Acacia* populations that are converted to even-aged scrub by browsing, cutting, ploughing and burning will not perform the services that maintain diversity in savanna. The impact that a plant or animal species has in an ecosystem may vary with the density, distribution and age structure of its population. The variability of function with demography is as relevant to the management of rangelands and fisheries as it is to the maintenance of diversity in nature reserves.

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Establishment of forage legumes on seasonally waterlogged lands in Zimbabwe

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Seasonally waterlogged lands (also known as vleis or dambos) are a key grazing resource during the dry season. However, the quality of mature grasses in vleis on sandy soils is generally low because of high fibre and low protein levels. Although legumes increase the intake and digestibility of high-fibre feeds, insufficient work has been done on the establishment of forage legumes in vleis. The poor establishment and low herbage yields of forage legumes in marginal rainfall areas have been attributed to lack of moisture and nutrients especially nitrogen and phosphorus. Three moisture zones with distinct vegetation types are recognized in vleis. It was therefore hypothesised that there are forage legumes that can grow in these zones. The experimental sites were grazed to leave grasses at about 50 mm height before sowing, and once every year during the dry season. Sowing was on cultivated strips that were 0.5 m wide and 0.5 m apart. Establishment and response to nitrogen and phosphorus of *Cassia rotundifolia* (cassia), *Stylosanthes guainensis* (stylo) and *Macroptilium atropurpureum* (siratro) sown at three different slope positions in grazed vleis at two sites were studied over four growing seasons. Cassia had the highest density, shoot weight and root weight ($P<0.01$). In contrast, densities of stylo and siratro were similar over the four growing seasons. Cassia produced more biomass ($P<0.01$) than stylo during the year of establishment while siratro seed did not germinate until the second season. Nitrogen had no significant effect on legume biomass, height and density. Phosphorus and a combination of phosphorus and nitrogen had a significant effect ($P<0.01$) on shoot weight of the legumes. Height, legume biomass and density varied ($P<0.01$) over slope position.

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Seedling recruitment of *Acacia karroo*

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Acacia karroo is a potential invader species of grasslands in the eastern Cape, and hence the factors which influence the regeneration phase of this species are important. To this end, a 2^3 factorial field experiment was conducted at two sites to assess the effects of shading, moisture availability, and vegetation structure (sward kept clipped) on the emergence and seedling establishment of this species. Shading had the strongest beneficial effect on emergence and survival in the first growing season, but apparently because of its influence on the soil moisture regime. This effect was increased by irrigation. Vegetation structure mainly affected the size and morphology of the surviving plants, but this effect was location specific. A second experiment addressed the influence of rotational grazing systems, using sheep, on seedling recruitment, but the experimental effects were obscured because of poor survivorship of seedlings, attributed to low rainfall. A third experiment assessed the recruitment of seedlings from seeds placed in cow dung pats, but none were observed to emerge. The implications of these findings for the invasion of grasslands by *Acacia karroo* are discussed.

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Seedling recruitment of *Themeda triandra*

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A four-year observational study was undertaken in a Transvaal savanna grassland to document the pattern of seedling recruitment of *Themeda triandra* in relation to rainfall variability and grazing. Results suggested that successful seedling establishment was influenced by moisture availability, seed availability, available space, competition from existing vegetation, and light, but this descriptive study was insufficient to separate out the relative effects of these factors. A full 2^5 factorial experiment was therefore conducted near Adelaide in the eastern Cape, with the following five main treatments: (1) irrigation; (2) shading; (3) removal of some tufts; (4) sowing of seed; and (5) clipping of vegetation. The emergence and survivorship of *Themeda triandra*, and of all other grass seedlings combined, was monitored from the beginning of the one growing season to the beginning of the next. The size of individuals was measured at the end of the first growing season. The results identified the strong constraint that seed availability has on seedling recruitment, but whose effect is dependent on sufficient moisture availability. Shading had a strong effect apparently mainly because of its effect on the soil moisture regime. Removal of tufts compounded the effects of clipping on the openness of the sward, which influenced the size attained by tufts. Implications of the findings for the re-establishment of *Themeda triandra* in degraded veld are discussed.

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Vegetation changes (1949-1971) in a semi-arid dwarf-shrub/grassland community in the Karoo, South Africa: influence of rainfall variability and grazing by sheep

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The influence of annual and seasonal (summer versus winter) rainfall variability and different seasons and systems of sheep grazing, including complete protection, on the botanical species composition of a community characterised by dwarf shrubs, annual and perennial grasses, and ephemeral dicotyledons, was investigated for 23 years in the Karoo, South Africa. Ordination and bivariate techniques revealed dramatic compositional changes in response to interregnal rainfall variability, mostly associated with annual or short-lived perennial vegetation components. Annual rainfall showed a pronounced temporal pattern of wetter 1950s and drier 1960s, with annual rainfall correlated with summer rainfall. The annual grass *Aristida congesta* and ephemeral

dicotyledons irrupted in certain years of suitable rainfall, the extent of which was influenced by grazing treatments. Perennial grasses and shrubs were strongly influenced by rainfall variation, with grazing treatments further influencing the rate and extent of change. Grazing during the summer only almost eliminated perennial grasses. Community change was mostly a result of rainfall variation, but the influence of grazing treatments became more important over a longer time period for longer-lived plants. The community is therefore a matrix of longer-lived perennial grasses and dwarf shrubs within which dramatic variations in the abundance of annual grasses and ephemeral forbs takes place. The need for long-term data sets and appropriate monitoring approaches for more complete understanding of forces determining community structure in semi-acid environments are discussed.

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Legumes for lambs

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Legume pastures of the species *Trifolium* and *Ornithopus* were used to determine the value of these pastures for finishing autumn-born lambs. The evaluated pastures include *T. resupinatum*, *T. vesiculosum*, *T. balansae*, *T. hirtum*, *O. sativus* and *O. compressus*. Ryegrass (*Lolium multiflorum*) was included as control since it is often used for finishing lambs in the winter and spring months. However, nitrogen fertilizer levels have increased the costs to such an extent that legumes provide an alternative that cannot be ignored. Two replicates (0.125 ha each) of each species were established under irrigation (25 mm per week) at Roodeplaat near Pretoria, South Africa. Camps were subdivided to facilitate a three-week rotational grazing system and pasture regrowth was measured. A put-and-take system was followed to determine optimum stocking rate for each one of the species and grazing days were calculated. South African mutton merino lambs were used in the animal growth trial. Grazing commenced during June with lambs with an average mass of 21 kg. Lambs were weighed weekly and slaughtered when a livemass of 45 kg had been reached. Cost per kg meat produced was calculated taking establishment and maintenance costs into account and costs were significantly lower on legumes than on ryegrass. Animal performance was higher on clovers and pink serradella than on ryegrass but significant differences ($P<0.05$) existed between the different clover species. The number of grazing days differed significantly ($P<0.05$), largely due to differences in lengths of growing periods. The serradella species had a very long regrowth period and poor animal performance was recorded on yellow serradella. Clovers are not readily included in intensive pasture systems because of the danger of bloat provocation. Foam formation of the legumes included in this experiment was measured *in vitro* to yield an indication of bloat. Using ryegrass as control, all the clover species exhibited a significantly larger volume of foam produced when mixed with a buffer in addition to significant differences ($P<0.05$) between clover species.

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Grazing patterns on *Themeda triandra* and *Tristachya leucothrix* in Highland Sourveld

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Patterns of defoliation on individual tufts of *Themeda triandra* and *Tristachya leucothrix* were monitored for three consecutive seasons, in each of three grazing treatments. The treatments comprised cattle, sheep, and an equal proportion of cattle and sheep (balanced in terms of animal units [AU]), each stocked at a rate of 1 AU ha^{-1}. All treatment paddocks were rested for a full growing season and burnt in late winter prior to the start of the trial. A four-camp rotational grazing management system was applied. Fifty plants of each species, in each of three grazing categories (ungrazed, leniently grazed and severely grazed), were marked in each of the treatments, before the end of the first grazing season. These plants were monitored at the end of every period of occupation for the remainder of the first grazing season and the two subsequent grazing seasons. Leaf table height and grazing category was recorded for each plant. These data were used to test

the hypothesis that the grazing pattern established in the first season of grazing after a burn was maintained for the following two seasons. Similar patterns were recorded for both grass species. In the cattle-only treatment, plants marked in the severe grazing category at the end of the first grazing season remained in that category during the following two seasons. There was a consistent and large decrease in the proportion of plants marked initially as ungrazed or leniently grazed, by the end of the second and third seasons. While similar trends were observed in the sheep-only and the cattle-sheep treatments, the magnitudes of changes in the proportion of plants which remained in their respective categories were not as large as in the cattle-only treatment. An important trend was that the proportion of plants in each of the three grazing categories in the sheep-only treatment changed the least over the period. Sheep, on their own and when mixed with cattle, tended to graze the same plants for the full recording period. This resulted in a 30% and 14% mortality of *T. triandra* plants, initially marked in the severely grazed category, in the sheep-only and cattle-sheep treatments respectively. Similarly, a 12% mortality was recorded for *T. leucothrix* plants, initially marked in the severely grazed category, in both the sheep-only and the cattle-sheep treatments. In the cattle-only treatment, the whole paddock tended to be evenly grazed with individual tufts less-severely grazed than when sheep were present and no plant mortalities were recorded. It is clear that the grazing pattern established in the first season after a burn is not maintained in subsequent seasons when the area is grazed at a relatively high stocking rate by cattle or by cattle and sheep together. With sheep-only grazing, however, the initial grazing pattern tends to be maintained.

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Trends in rangeland composition on ranches in the north-western Transvaal

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The composition of the herbaceous layer was measured in the Mixed Bushveld of the north-western Transvaal. Relations between herbaceous composition and determinants considered important in influencing herbaceous composition were quantified. Rainfall for the season preceding the vegetation survey and grazer stocking rates had a significant additive effect on rangeland composition. Under these conditions, a stocking rate of around 6.3 GU per 100 ha was considered appropriate. Follow-up surveys, undertaken at two yearly intervals, confirmed the importance of annual rainfall and stocking rate. The usefulness of the laid-down agricultural stocking rate for arid and semi-arid savannas is questioned, and is replaced here by an existing model which predicts animal biomass from rainfall. There was no change in the herbaceous species composition significant enough to warrant an adjustment in the stocking rate as recommended above.

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The evaluation of ammonium nitrate solution as a fertilizer on planted pastures

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The use of ammonium nitrate solution (ANS) on planted pastures, is a relatively new concept in South Africa. As a result, there are no research results on the reaction of pastures to this type of fertilizer. ANS and the granular formulation of limestone ammonium nitrate (LAN) on planted pastures were compared in an *Eragrostis curvula* pot trial conducted in a controlled environment at the University of Pretoria. Pots with a volume of 10 L were filled with 12 kg of soil after they were lined with plastic to prevent leaching. Three soils were used, a clay (46% clay), a loam (25% clay) and a sandy loam (14% clay). The pots were sown with *Eragrostis curvula* in mid-August and were then watered every two to three days to 90% of field capacity, with de-ionised water. ANS and LAN were applied at the end of September at levels equivalent to 75 and 150 kg N ha^{-1} a^{-1}. At that stage the grass had reached a height of approximately 100 mm. Following the application of the fertilizer, a third of the pots were watered immediately, another third 24 hours later and another third, five days after application of fertilizer, to determine the effect of volatilization. Each treatment combination

was replicated three times. The grass was cut to a height of 70 mm when it reached the early flowering stage to determine dry matter (DM) production. At the end of the season, stubble mass was also determined. On the clay and sandy loam soils, the plants that received ANS produced significantly (P=0,01) more, with no significant difference on the loam soil. Increasing the N level from 75 to 150 kg N ha^{-1}, resulted in a highly significant increase in DM production. This increase was, however, much greater on the loamy soils than on the clay soil. On the loamy soils, there were no significant differences in production when the pots were watered immediately after N application or 24 hours later. The five days delay in irrigation, however, resulted in a highly significant increase on the sandy loam and a highly significant decrease on the loam soil. On the clay soil, there was already a highly significant decrease with the first delay in irrigation, with a further highly significant decrease with the five day delay. The stubble mass (which may be an indication of the vigour in the next growing season) obtained with ANS, was significant higher than with LAN. There appeared to be an advantage in using of ANS on certain soils. There is a need for further research into soil factors that may influence the effectiveness of different N fertilizers. In this trial, the quantity, balance and characteristics of the different fractions may have played a part. Although the results were not very consistent, there is evidence of possible losses due to volatilization, with both fertilizers.

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The influence of nitrogen fertilisation and physiological maturity on the yield and nutritive value of *Panicum maximum* cv. Gatton

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Panicum maximum, although indigenous to many veld types in South Africa, is only now becoming popular as a pasture. Apart from information on the adaptive range of the species, it is necessary to quantify the response of the pasture to the level of nitrogen fertilisation and physiological maturity, before recommendations on its use in livestock production systems can be made. With this as an objective, a series of clipping and grazing trials have been conducted on the Hatfield Experimental Farm of the University of Pretoria. This report covers the description of the available pasture on both clipping and grazing trials over a two-year period. Data on the actual intake and partial digestion of such herbage will be covered in a subsequent report. In these trials nitrogen fertilisation treatments, ranging from 0 to 150 kg N ha^{-1}, were evaluated at a range of different ages, from 18 to 105 days after the application of nitrogen. Phosphorous and potassium applications, based on soil analyses, ensured that these nutrients were not limiting. All physiological stages - from short leafy to boot or piping stage to full flower - were evaluated. The evaluation parameters were grouped into pasture structure and availability, quality parameters, and anti-quality factors. With respect to pasture structure and availability, the amount of herbage on offer, the height of the pasture, the height of the leaf canopy and the number of flowering tillers all responded positively to both the age of the pasture and the level of nitrogen fertilisation. These data, although not always indicative of pasture quality, do provide valuable information on the suitability of pasture for different classes of livestock, for different usages (grazing, hay, seed production) and potential grazing capacity. When considering parameters having a more direct bearing on quality the response to age and nitrogen did not always follow the same trend. Hence, whereas the crude protein (CP) content, and digestibility declined as the pasture became more mature, from 20% to 8% and 75% to 57% respectively, the dry matter (DM) content increased from 24% to 37% and the total non-structural carbohydrates (TNC) from 27 to 37 g kg^{-1}. Conversely, while the DM content declined from 35% to 27% as the level of nitrogen was increased, the CP was increased from 11% to 17% and TNC and digestibility were indeterminate. With respect to anti-quality factors such as NDF (as a measure of cell wall content) and nitrate nitrogen (which could have a chronic, if not toxic, effect on livestock), the former increased with age and declined with fertilisation while the latter followed the reverse trend. These data provide the basis for management strategies affecting pasture area, grazing capacity, type of livestock and livestock production by manipulating the level of nitrogen fertilisation and physiological maturity.

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Agronomic evaluation of local *Cajanus cajan* for fodder production in Uganda

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There is serious feed shortage of high nutritive value for livestock feeding during the dry seasons when the grasses are coarse and stemmy and hence of low quality. Crude protein content of the grasses may fall below the limiting percentage (7%) and this tends to lower animal production. Currently, emphasis has been placed on *Luecaena leucocephala* as a multipurpose fodder legume to supplement livestock, feeding especially dairy cattle. Unfortunately, *Leucaena* has now been invaded by the psyllid pest (*Heterospylla cubana*) and there is an urgent need to develop alternative feed resources for the cut and carry production systems in the country. Four local varieties of *Cajanus cajan* were evaluated at Makerere University Agricultural Research Institute, Kabanayolo, for one growing season to assess initial agronomic performance (germination, establishment, seedling survival, diseases and pests, leaf retention, height growth), fodder production and partitioning of DM and coppicing ability. Nodulation of the varieties was also assessed. The results show that the four local varieties had high germination percentage (84-93%) under field and controlled conditions and there were no significant varietal differences in germination. One local variety (Agogi) was superior in terms of establishment, height growth, and fodder production. A common feature to all the four local varieties was a slow accumulation of dry matter during the first 50-60 days of growth but this increased rapidly after 73 days. At 67 days after sowing, dry matter accumulation was more in leaves but it declined during pod-filling stage. The three varieties (Apir-Elina, Apio-Ogali and Apio-Agweng) matured earlier at 137 days while Agogi matured at 183 days. A late maturing variety is more suitable for fodder production since it accumulates more dry matter and retains leaf much longer. The crops would be well integrated in the crop/livestock production systems because the plants supply seeds which are consumed by humans and fodder for livestock. They normally mature during the dry season when feed shortages are at their peak and therefore would bridge the dry season feed gap.

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An economic assessment of overwintering merino ewes and lambs on *Lolium perenne* and *L. multiflorum* in East Griqualand

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Overwintering of sheep in East Griqualand (EG) is a recognised farm management problem. The natural sour grassland vegetation provides forage of adequate nutritional quality for sheep in summer, but its nutritive value declines to sub-maintenance levels in winter. The objective of this study is to assess the economics of cultivating two temperate grass pastures - an annual and a perennial - under irrigation for overwintering autumn lambing Merino ewes and their lambs in EG. Trials conducted at Kokstad (30°31'S, 29°25'E; Bioclimatic sub-region 4f) from 1988 to 1991 compared lamb performance (livemass gain) on rotationally grazed *Lolium multiflorum* cv. Midmar - planted annually in February on a Hutton soil - and an existing *L. perenne* cv. Nui pasture (planted in 1987 on a Newport soil). Nitrogen (N) fertilization rates were 280 and 302 kg N ha^{-1} a^{-1} for *L. multiflorum* and *L. perenne*, respectively. Two stocking rate (SR) treatments (low, high) were applied to each pasture: initially 20.0 and 27.8 dam-lamb pairs per hectare on *L. multiflorum*, 16.3 and 24.1 dam-lamb pairs per hectare on *L. perenne*. Lamb stocking rates were doubled - by halving the pasture area - after weaning because of the increased rate of pasture growth in spring. Dams were removed from the pastures at weaning and fed *Eragrostis curvula* hay until October, after which the natural grassland was grazed. Corresponding mean final lamb livemasses (approximately 140 days *post partum*) and gross margin (GM) (R ha^{-1}) values, expressed in terms of 1993 prices, were consistently higher on *L. multiflorum* than on *L. perenne* across all treatments. Sensitivity analyses using three lamb auction prices (low, average, high) were conducted for the initial and doubled stocking rates - assuming that weaned lambs were bought in to double the stocking rate over the entire pasture area. For *L. multiflorum*, GMs ranged from -R611 to R316 ha^{-1} for

the initial low stocking rate, and -R118 to R831 ha^{-1} after doubling this stocking rate. The corresponding ranges in GM for the high stocking rate were -R476 to R1 153 ha^{-1}, and -R61 to R2 328 ha^{-1} respectively. Similarly, for *L. perenne*, GMs ranged from -R1 560 to -R322 ha^{-1} at the initial low stocking rate and -R1 496 to R322 ha^{-1} after this stocking rate was doubled. At the high stocking rate, the corresponding ranges in GM were -R1 246 to R475 ha^{-1}, and -R1 170 to R737 ha^{-1}, respectively. Results emphasize the effects of stocking rate management and price monitoring on GM, particularly as a unit change in lamb price *ceteris paribus* resulted in a more than proportional change in GM. *Lolium multiflorum* appears, in terms of lamb performance and GM, to be more favourable than *L. perenne* for overwintering productive sheep in EG.

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Root biomass, spatial distribution and relations with aboveground leaf biomass of *Colophospermum mopane*

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The investigation was conducted during 1992 on an area north of the Soutpansberg, covered by dense stands of *Colophospermum mopane* and yielding no grass cover. Ten sites which differed in tree density were randomly selected. In the middle of each site a hole was dug around a column (monolith) of soil and trimmed to an exact column of soil of 2.0 m x 0.5 m x 1.0 m (1 m^3). The soil of each monolith was removed in 5 layers of 200 mm. The roots were separated from the soil by hand washing, using fine-mesh sieves (0.5 mm^2). The roots of each soil layer were sorted into four classes (0-1.0 mm, >1.0-5.0 mm, >5.0-10.0 mm, >10.0 mm), dried to a constant mass (70°C) and weighed. Eight concentric blocks that increased in size with increments of 2 m around each excavation were demarcated at the ten excavation sites (1 105 m^2). The canopy dimensions of all rooted *C. mopane* plants in these blocks were measured and the leaf dry mass of each tree was estimated using a regression equation which relates spatial canopy volume (independent variable) to leaf dry mass (dependent variable):

$$\ln y = -4.165 + 0.711x.$$

Mean total root biomass of the ten excavations was 17 354 kg ha^{-1} (range: 9 760 kg ha^{-1} - 29 790 kg ha^{-1}). Of these 19% were in the 0-1.0 mm diameter class, and 20.3%, 16.2% and 44.5% in the >1.0-5.0 mm, >5.0-10.0 mm and >10 mm diameter classes respectively. A mean of 66.1% of all fine roots (<5.0 mm) was found within the first 400 mm of the soil. The coarse roots (>5.0 mm) were sparsely distributed or completely absent within the 0-200 mm soil layer, with the highest concentration between 200-600 mm. Mean total leaf biomass was estimated at 1 082 kg ha^{-1} (range: 627 kg ha^{-1} - 1 709 kg ha^{-1}), which was significantly lower than the root biomass. Multiple regression analyses were used in an attempt to determine at which distance from the excavations will trees still be accounted for in the root biomass. Leaf biomass of trees within the eight blocks around the root excavations were used as independent variables after testing for correlation among the variables (using principle components analysis). The most variation in the root biomass of all tested root fractions were explained by the leaf dry matter fraction of blocks 7 and 8 combined. This implies that the roots of trees at a mean distance range of 12.6 m to 16.6 m (interval: 14.6 m) away from the monoliths are accounted for by the roots present in the monoliths. Based on a mean tree height and a mean canopy diameter of 1.91 m and 1.17 m respectively, it is estimated that the roots of these trees extended horizontally to a distance of approximately 7.6 times their height and 12.5 times the extent of their canopies.

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Grass/shrub interactions in the semi-arid and arid rangelands of southern Africa

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Long-term grazing and consequent desertification in the semi-arid and arid rangelands of southern Africa have led to the dominance of the vegetation by dwarf shrubs. These factors coupled with forthcoming climatic

changes associated with global warming raise important questions about future patterns of vegetation dynamics and productivity in these rangelands. This study investigates the interactions between palatable grasses, that have largely been eliminated from their original distributions, and shrubs that presently dominate the vegetation in the western Karoo, South Africa. The study was conducted at two sites near Richmond and Prince Albert in the Cape Province where the mean annual precipitation is 318 mm and 156 mm respectively. Four field experiments were established to determine the survival, tiller production, plant mass and flowering of the grasses, *Themeda triandra* and *Eragrostis curvula*, transplanted under and in the interstices of the shrubs, *Eriocephalus spinescens*, *Ruschia spinosa*, *Lycium* sp. and *Pentzia globosa*. Plants of *T. triandra* were grazed by small stock for one day to two days in two of the experimental plots. Differences in survival, growth and flowering were compared using χ-square and Wilcoxon-Mann-Whitney tests. In the absence of grazing, more *T. triandra* plants survived under *R. spinosa* than in the interstices. Plants growing under *E. spinescens* and in interstices, and under *R. spinosa* and *Lycium*, survived equally well. *Themeda triandra* produced more tillers under *Lycium* than under *R. spinosa*. No differences in tiller production occurred between plants growing under *E. spinescens* and *R. spinosa* and those growing in their interstices. In the ungrazed *R. spinosa* plot, no differences in plant mass occurred between grasses growing under shrubs and in the interstices. In the *E. spinescens* plot, more *T. triandra* plants were grazed in the interstices than under the shrubs. Thirty-nine days after grazing, grazed plants produced more tillers and a greater plant mass than ungrazed plants. Approximately the same number of *T. triandra* plants were grazed under *R. spinosa* and *Lycium* shrubs but more tillers were grazed per plant under *Lycium*. Twenty days after grazing, grazed plants growing under *R. spinosa* produced more tillers and a greater plant mass than ungrazed plants. *Themeda triandra* did not flower at either site. *Eragrostis curvula* plants grown under *P. globosa* shrubs and in interstices did not differ in their survival, tiller production or flowering. Competitive interactions between grasses and shrubs are of minor importance in these rangelands. More *T. triandra* plants survived under *R. spinosa* than in the interstices otherwise tiller production and plant masses of *T. triandra* and the survival, growth and flowering of *E. curvula* were unaffected by their positions in the field. Vegetative growth of *T. triandra* was, however, stimulated by short periods of cropping by small domestic stock. Given the right rainfall regime, the range expansion of palatable grasses back into their former distributions is possible.

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Drought adaptation on the cell water level of four temperate pasture species

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A previous field trial conducted on the Hatfield Experimental farm in Pretoria showed that arrowleaf clover was much more drought sensitive than oats, triticale and Italian ryegrass. It is known that drought adaptation mechanisms on the cell water level may lead to photosynthesis being maintained at low water potential levels. The aim of this study was to ascertain what role adaptation on the cell water level played to account for the differential responses to drought of the various pasture species in question. Psychrometers were used in a pot experiment to determine the water and osmotic potential of leaves. The difference between the two potential components was taken as pressure potential. Relative water content was determined at the same time by weighing fresh, dry and turgid samples. Turgidity was attained after leaving the samples for four to five hours in distilled water. Relative water content is an estimate of cell volume. Hoffler diagrams were constructed to illustrate the relation between relative water content and the various water potential components of the plants. Inferences about the type of adaptation can be made from these relationships. It was shown that oats and triticale did not adjust osmotically but increased the ratio of bound water to active water (free water). Thus, the osmotic potential was decreased more drastically when dehydration developed and cell volumes decreased. Such a mechanism may lead to sustained positive pressure potentials at lower levels of dehydration. Ryegrass did not adapt on the cell water level. Arrow leaf clover adapted to water stressed conditions by developing less elastic cells. The reduction of cell elasticity could be seen as a disadvantageous adaptation, since more elastic cells are advantageous for the maintenance of turgor when plants are dehydrated. An ultrastructural study of leaf surfaces confirmed that arrow leaf clover developed less elastic cells when grown under water stressed levels. It seems that increasing the ratio of bound water to free water is an important and

successful way of adapting to water stress and that this mechanism might explain to a large extent why oats was found to be very drought tolerant in previous field trials. The drought sensitivity of arrow leaf clover might be explained on the physiological level but this study also showed that certain features developed under stress which could be conducive to drought sensitivity.

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A framework for the development of a management-orientated vegetation model

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It is alleged that current vegetation research efforts do not meet the information requirements of land managers. This is because the research work is often esoteric, and if potentially useful, then seldom presented in an integrated and practicable applicable manner. This paper presents a philosophical framework which attempts to address these shortcomings. It centres around the development of a vegetation model. This model, essentially a state-and-transition model, also incorporates a system of evaluating the vegetation in terms of various land-use options and translating these onto maps. Without this addition, one cannot talk about desirable or undesirable change. If we cannot talk in these value-loaded terms then we cannot communicate the consequences of vegetation change to the public or inform the pastoralist of the adverse (or positive) consequences of his actions. An iterative approach is suggested where a prototype is first developed, evaluated and then upgraded if necessary.

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Cowpeas *(Vigna unguiculata)* as a planted pasture

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The cowpea is a legume crop high in protein as well as in other essential nutrients, and is highly compatible in intercropping with a wide range of crops. In southern Africa, cowpeas play an important role as a hay and fodder crop - the hay produced is of a very high quality, and is, in fact, a complete diet. The name 'cowpea', however, originates from the fact that cowpeas were traditionally grazed by cattle. The objective of this study therefore, was to determine whether cowpeas can withstand grazing as well as being utilised as a fodder crop. If so, at what frequency and intensity should they be grazed. It is hoped that this study will show that cowpeas have uses other than purely as a fodder crop. A cutting trial comprising 15 selected lines was run to determine the grazing tolerance and the optimum grazing height of the lines. The treatments were as follows: T0 - no cut (control), T1 - plants cut to a height of 300 mm and T2 - plants cut to 150 mm. All treatments were cut once during the season to simulate grazing, and harvested at the end of the growing season for hay or silage. Six lines had a significantly higher dry matter yield than the other nine when cut to 150 mm and therefore were considered to be more suitable for grazing. T2 (150 mm) had a significantly higher dry matter yield than the other two treatments and thus was used in further trials. A cutting frequency trial was run to determine how many defoliations could be removed during one season. The following treatments were used: T0 - no cuts (control), T1 - plants cut once during the season, T2 - plants cut twice, T3 - plants cut three times. T3 (three times) produced significantly higher ($P<0.05$) dry matter yields than the treatments with less cuts and it appears therefore that cowpeas can withstand frequent defoliations. Certain lines responded more favourably to defoliation than did others, which led to the selection of defoliation tolerant lines. Drought tolerance of cowpea lines was also investigated in the above trials, which has resulted in the selection of five lines which are more drought tolerant than the other lines. This whole study has led to the development of a line which has been submitted for cultivar release.

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Assessment of forage legumes as protein-rich supplements for ruminant animals in Zimbabwe

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Forage legumes have become increasingly important in Zimbabwe as protein-rich forages to supplement a basal diet of either grass or poor quality roughage for ruminant livestock. For smallholder milk production in particular, legumes are needed to provide a balanced diet along with a forage such as Napier fodder (bana grass) to sustain lactation yields of 2 000 L. A large number of species of either herbage or shrub legumes have been established in Zimbabwe and there is a need to assess their suitability, especially with respect to the efficient utilization of protein, for ruminant production systems. This paper indicates an appropriate scheme for such an assessment and gives results for 14 different species, seven of which are herbage legumes and seven of which are shrub legumes. The scheme proposed includes the measurement of total N and how much is rumen degradable (RDN) and not degradable (UDN). Subsequent fractionation of RDN indicates the portions which are quickly or slowly degradable. Further analysis indicates whether UDN is available to the animal by the measurement of acid detergent insoluble nitrogen (ADIN). Measurement of neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) indicate total cell wall content and its nature and provides a guide to digestibility of organic matter. The contents of certain antinutritional factors, especially condensed tannins, lectins and saponins are determined to indicate whether the forage legume is acceptable and safe to feed. The total N content of the 14 species varied widely from 17.4 to 46.7 g kg^{-1} M, with that of the shrub legumes being considerably higher than that of the herbage legumes. The fraction of total N which was degradable differed between species from 0.57 to 0.97. A large part of the undegradable N in some species appeared to be not available to the animal. The ADIN content varied considerably with that of the herbage legumes being inversely related to protein degradability. The fibrosity of the legumes varied three fold as given by NDF content, while the ADF content varied four fold. Two of the herbage legumes and three shrub legumes contained appreciable amounts of condensed tannins and the same species plus another shrub legume displayed a high lectin activity. These and other results indicate that the suitability of these legumes for ruminant feeding is likely to differ appreciably, but the above scheme of analysis is likely to provide a means of selection of appropriate legumes for more detailed examination.

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Fire regime of the Kruger National Park for the period 1980 to 1992

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Fire regime refers to the type and intensity of fire and the season and frequency of burning. In the Kruger National Park it varies according to the source of ignition of the fires. Since 1980 the different ignition sources have been controlled burns (47%), refugees (24%), others (20%) and lightning (10%). The data showed that anthropogenic fires were the most common fires and evidence on a global scale would suggest that the *status quo* will be maintained even if controlled burning is discontinued as is currently being considered by the National Parks Board. The most common type of fires that occur in the Park are surface head fires burning with the wind, but back fires and crown fires do also occur. The intensity of the fires is primarily a function of the grass fuel load which is dependent on the rainfall and consequently varies enormously from year to year. The type of fire also influences the intensity and research conducted during 1992 showed that head fires burning under similar environmental conditions were on average 36 times more intense than back fires. Anthropogenic fires generally occurred during the dry, dormant, winter period while lightning fires were more associated with the spring and summer period when dry lightning storms occur. The frequency of burning varied significantly between sourveld and sweetveld. The mean frequency of burning in sourveld areas was triennial and in the sweetveld areas octennial. Finally the general conclusion that can be drawn about the fire regime of the Kruger National Park is that it is highly variable and will continue to be so in the future. This is a very positive feature that ensures a wide diversity of habitat types.

Remote sensing: a tool in a GIS spatial database to characterize veld condition

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The study area covers 1 407 km² of mainly Mixed Bushveld in the north-western Transvaal. Two SPOT satellite images covering the area were enhanced by principle component analysis and classified according to large ecological groups on an image processor. The classified image was exported in an ERDAS format from the map and image processing system (MIPS) and imported in the analytical module of a geographic information system (GIS), where the spatial analysis (SPANS) software package was used to quantify inter-correlated relations with pre-processed land types, vegetation and geology maps. The images were then classified into four veld condition classes by treating the ecological units separately. This was done by using water points and fence-line effects as training areas in an onscreen mapping process. Extensive field work was also undertaken and 140 sample plots were placed on grazing gradients. The sample plots of each vegetation-habitat type were subjected to multivariate analysis. Thus it is clear that the species composition of a sample plot reflects the position of the sample plot on a grazing gradient. The resulting veld condition map consists of respectively heavily, moderately and lightly over-utilized veld and veld in a good condition. This map was also imported into the GIS. The percentage coverage of each ecological unit by the different veld condition classes was determined. It was subsequently possible to quantify the proneness of the various vegetation and habitat types to degradation due to overgrazing. According to this analysis only 54% of the area was in good condition while 11% was heavily utilized. The vegetation on sandy soils were mostly in good condition but a large part of the vegetation on the clayey soils was heavily utilized, and consequently in a much further stage of degradation, especially with regard to the herbaceous species composition and an increase in woody species. It is concluded that satellite imagery can be very useful to assess large areas in combination with traditional veld condition assessment techniques in a way that was not previously possible. In a GIS environment, such a spatially distributed veld condition map can be a key input in grazing-capacity models together with other spatial data to depict realities of geographically distributed entities more accurately. It should be noted that without sufficient knowledge of the area's ecology, the benefits of this approach may be greatly reduced. However, this new technology may help in gaining a better understanding of the spatial relationships between entities in a specific ecosystem.

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The oversowing of an annual legume in perennial grasses

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The oversowing of annual temperate legumes in perennial pastures has two objectives, viz. the transfer of fixed nitrogen to the grass component, and to determine the productive utilization of the soil during both winter and summer. Twenty kilograms of *Trifolium resupinatum* was oversown during May of 1991 and 10 kg of the same during May 1992, into established pastures of *Pennisetum clandestinum, Cenchrus ciliaris* and *Chloris gayana*. In 1992 the oversown plots were divided in half and only one half was oversown. This was done to determine whether any residual nitrogen had an impact on the production of the three grasses. Oversowing of the clover was performed using the following cultivation practices and two different sowing methods (ie. broadcast and row planting): (1) rip, spraying with grammoxone, broadcasting of seed and roll; (2) rip, broadcasting and roll; (3) grammoxone, broadcasting and roll; (4) broadcasting and roll; (5) grammoxone followed with row planting; (6) row planting; (7) grammoxone and no oversowing; (8) rip and no oversowing; (9) rip, grammoxone and no oversowing; (10) no cultivation or oversowing. The yields obtained indicated that the clover had been well established. The crude protein of the grass component increased significantly in the plots where the clover was oversown. Results indicated that the presence of clover was equivalent to adding 60 kg N ha^{-1} to the grasses each season.

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Browsing-induced compensatory mechanisms of two karoo shrubs, *Eriocephalus ericoides* (L.f) and *Pteronia tricephala* (D.C.)

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Functional responses to browsing by sheep were investigated at different stocking rates in two karoo shrubs to determine whether these species compensate for the browsing-induced loss of nitrogen capital, transpiration surfaces and photosynthetic carbon gaining potential. Under heavy browsing pressures, *Pteronia tricephala* improved its day-time plant water balance which resulted in elevated photosynthetic rates. Browsing-induced improvement of plant water status or elevation in photosynthetic rates were not observed at lower stocking rates for *P. tricephala*, or at any of the stocking rates for *Eriocephalus ericoides*. Both species were found to benefit with respect to nitrogen allocation under heavy browsing. Heavily browsed *E. ericoides* appeared to maintain existing nitrogen uptake rates, while *P. tricephala* re-allocated nitrogen from stems and roots to the leaves under the most intense stocking rate. Browsing reduced the average level of chemical defense (total polyphenols) in the leaves of both species, irrespective of stocking rate. These results confirm that the two species differ widely in their responses to browsing and that these responses are not generalizable over all stocking rates. The findings further suggest that browsing-induced compensatory mechanisms operate only at heavy stocking rates with negative or no effects at lower browsing pressures. *Pteronia tricephala* appears to respond more positively (than *E. ericoides*) to severe browsing which may benefit the survival ability of severely browsed plants which in turn could explain the present increaser ecological status of this species in the karoo. Severe browsing of *P. tricephala* caused a reversion to the juvenile-phase (i.e. elevated plant water status, net photosynthesis and leaf nitrogen levels). These responses coupled with the reduction in polyphenol levels may result in increased palatability and nutritional quality which may facilitate continued utilization of this generally unpalatable species at higher stocking rates. In contrast, relatively more palatable species, such as *E. ericoides*, appear to have few or no compensatory mechanisms at any of the stocking rates which may explain the poor survival ability of more palatable shrubs when browsed. The results suggest that moderate browsing may not be more beneficial (or less detrimental) than a severe browsing episode, and that adequate rests between browsing episodes are far more critical than browsing intensity *per se* in determining survival of browsed karoo shrubs.

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Clonal growth and intraspecific competition in *Centropodia glauca* (gha grass)

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Centropodia glauca reproduces vegetatively by producing ramets outwards, thus increasing the size of tufts. Central tillers eventually die, probably as a result of limited space and a phosphorus deficiency, resulting in circular associations of tufts (clones). All nutrients, excluding phosphorus, occur in higher concentrations in soil samples from the centre of the clones than from adjacent areas. The distances between clones and their two nearest neighbours were significantly shorter for smaller clones than for larger clones, indicating a spatial arrangement that would reduce interference between clones. Linear regression of combined nearest neighbour tiller index against the distance between nearest neighbour pairs within the clones, was significantly positive, indicating the existence of competition between tufts. The study supports the hypothesis that competition can influence the structure of higher plants.

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Response of the herbaceous vegetation on an eastern Transvaal game ranch to large herbivore stocking rate and rainfall fluctuations

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An integrated large herbivore and vegetation monitoring programme has been ongoing on Madrid Game Ranch in the eastern Transvaal Lowveld since 1989. The vegetation monitoring grid was overlaid on the permanently marked, cut transect lines making it possible to integrate the vegetation and large herbivore data collected. The vegetation monitoring programme entails measurements of herbaceous biomass, herbaceous canopy cover, mean grass height and herbaceous species composition. Baseline measurements were made in March 1989, and were repeated in March 1990, 1991 and 1993. Population estimates of key species were obtained during the large herbivore population monitoring programme. One component of this programme entails line transects which were censussed in September of 1989, 1991 and 1993. The occurrence of a severe, multiple-year drought during the above monitoring period made it possible to monitor the response of the herbaceous vegetation to large herbivore stocking rate and rainfall. During the 1990/1991 rainfall year, the rainfall received was 37% below the long-term mean. In the following rainfall year, only 50% of the mean annual rainfall was measured. Since September 1989, the biomass of large herbivores has increased from 2 510 to 5 410 kg km^2, and currently is close to the mean predicted biomass based on the Coe, Cumming and Philipson predictive equation. By active management of certain large herbivore populations, the contribution that bulk grazers made to the total biomass was increased from 26% in 1989 to 42% in 1993. Similarly, the contribution made by mixed feeders was decreased from 35% in 1989 to 17% in 1993. The proportion that concentrate grazers and browsers contributed to the total herbivore biomass remained constant. Herbaceous biomass, herbaceous canopy cover and mean grass height responded strongly to fluctuations in annual rainfall and not to total large herbivore biomass nor to grazer and mixed feeder biomass. There was a consistent trend towards a decrease in increaser II species and a increase in decreaser species between 1989 and 1991, but this trend was reversed between 1991 and 1993. Of those herbaceous species contributing more than 5% to the total herbaceous biomass, *Digitaria eriantha* showed a constant decline between 1989 and 1993, while *Urochloa mossambicensis* and forbs initially declined between 1989 and 1991, but then increased between 1991 and 1993. *Panicum maximum* showed the opposite trend. It is hypothesised that the above responses are largely due to the multiple drought years in 1990/1991 and 1991/1992, and not to the increase in large herbivore biomass. Future monitoring will hopefully confirm this. Based on these responses, guidelines for the future management of large herbivore populations are suggested for game ranching enterprises which have as their objective the breeding of rare and endangered species.

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CONGRESS 29 POSTER ABSTRACTS

Effect of mechanical brush clearing on botanical composition and soil characteristics of a *Euclea undulata/Acacia senegal* savannah

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The trial was located in Maputo Province, Mozambique, in deep compact sandy soils, 32° 4' E and 26° S. Annual rainfall averages 664 mm in the study area. Woody and herbaceous components as well as soil characteristics were studied in adjacent areas in which the last mechanical brush clearing had taken place 7, 2 and 0 years previous to the study. Previous to those years, regular yearly clearing had taken place. Woody vegetation samples were studied in 5 m x 8 m quadrats in the 7-year stand, 15 m x 15 m in the 2-year stand and 20 m x 20 m in the regularly cleared area (n=8 for each area). Only plants 0.5 m high or more were considered. All these areas were grazed at first but because of the brush encroachment, grazing was gradually abandoned the 7-year stand, while only a few animals grazed the 2-year stand, and many grazed the cleared area. Herbaceous vegetation was measured from three 1 m x 1 m quadrats located in each of the quadrats described above. Superficial soil (0-50 mm deep) samples (n=8) were also collected in each quadrat. The number of woody species and their diameter increased with stand age, as did the density and the biomass. *Euclea undulata* and *Croton menyhartii* predominated in the 7-year stand, while *Acacia senegal* and *C. menyhartii* predominated in the 2-year stand. *Acacia senegal* and *Carissa bispinosa* predominated in the 0-year stand. *Urochloa mossambicensis* and *Themeda triandra* were dominant in the herbaceous layers of the regularly cleared areas while no specific herbaceous species dominated the 7-year stand. Soil organic matter (OM) decreased (P=0.001) with years since clearing from 3.8% to 2.6%. In a probable relation with decreasing OM, total nitrogen (Nt), total phosphorus (Pt) and pH also decreased (P=0.001, P=0.004 and P=0.03 respectively). Available phosphorus (P) was undifferentiated ($P>0.05$) among the three areas with an average of 7.25 mg per 100 g of soil, although it was 45% higher in the 2-year stand. The study suggested that biomass of woody species increased without brush clearing, while soil OM, Nt and Pt decreased. These changes in soil mineral status may also be related to the presence of grazing.

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Restoration of Kalahari dune vegetation: a mycorrhizal perspective

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On southern Kalahari dunes, denuded of vegetation through overgrazing, plant re-establishment is severely compromised by environmental conditions which include low rainfall, an unstable surface, and low soil nutrient status. It is hypothesised that many plant species will be unable to establish without the development of mycorrhizas to facilitate nutrient uptake. However, because of the absence of plants on denuded dunes, it is predicted that inoculum levels of the obligate mutualistic mycorrhizal fungi will be very low. This was tested in a mycorrhizal bioassay and by mycorrhizal spore counts from sand collected at various positions on stable and unstable dunes. Mycorrhizal spore levels were very low, and were absent from areas of moving sand. Soil from the rhizosphere of *Centropodium glaucum* had the highest number of spores and only this soil infected the bioassay plants. These results indicate that lack of mycorrhizal inoculum may compromise plant establishment. The selection of a suitable revegetation strategy will be discussed from the perspective of the mycorrhizal ecology of the vegetation.

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Analysing vegetation dynamics of South Africa in near-real time with NOAA/AVHRR satellite data

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A routine system is described whereby monthly NDVI (normalized difference vegetation index) maps are produced from full resolution NOAA/AVHRR local area coverage (LAC) satellite data. These time series provide "quick-look overviews" of vegetation dynamics of the whole of southern Africa. Comparison of current NDVI maps with historical reference NDVI maps allow detection of vegetation changes at national, regional and even district level in near-real time. This early detection of vegetation changes over time could serve as a useful indicator of climatic perturbations (e.g. drought) and assist land owners and decision makers in formulating and executing optimal management strategies in order to counteract adverse effects.

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Addressing the bush encroachment problem in Namibia with satellite remote sensing

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A study was conducted to investigate the potential use of satellite remote sensing to identify bush encroachment at national and farm level in the Grootfontein-Otavi area of Namibia. NOAA/AVHRR and LANDSAT Thematic Mapper (TM) digital data captured on 12 June 1989 were used as satellite data base, while ground information of 17 farms were obtained from extension officers in the region. The technique used was to compute the normalised difference vegetation index (NDVI) for each pixel in order to define high and low chlorophyll activity. Each pixel, with its specific NDVI-value, was grouped into a NDVI class by a density-slice process. A colour was assigned arbitrarily to each class, ranging from red (bare soil) to cyan (dense vegetation). By using the spectral separability of bush encroached versus debushed areas during this time of the growing season, a 96% identification accuracy was obtained at farm level with LANDSAT TM data. The coarse resolution NOAA/AVHRR data, on the contrary, failed to provide accurate identification at farm level. At a national scale, however, it reflected a good synoptic overview of the situation as a whole. It is concluded that initial results of this study indicate promise in using satellite remote sensing as a bush encroachment assessment tool. For monitoring purposes a multi-temporal comparative analysis is suggested on an annual basis. Furthermore it is strongly recommended that detailed field surveys should support remote sensing studies to ensure accurate calibration and interpretation of the satellite data.

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Fodder banking economics model

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A model analysing the economic implications of fodder banking was developed to determine the major driving variables affecting the economic success or failure of a particular feeding strategy. Comparisons are made between stored feed, bought feed and varying stock numbers for a particular site and client. A number of economic input variables specific to the client are included. The major variable affecting the success of any feeding strategy is the number of animals being run on the property. The model allows for an analysis of the effect of herd size on the profitability of any strategy. A case study is presented where the optimum breeding herd size determined for the Adelaide production system, is compared with other means of estimating the optimum herd size.

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The growth responses of two ecotypes of *Themeda triandra* transplants along an altitudinal gradient in Natal: some preliminary results

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Transplants (seedling and tillers) of *Themeda triandra* collected at Cathedral Peak (1 800 m a.s.l.) (Drakensberg ecotype) and Umfolozi Game reserve (90 m a.s.l.) (Zululand ecotype) were planted in cleared gardens at Cathedral Peak, Pietermaritzburg (740 m a.s.l.) and Umfolozi Game Reserve in October 1992. Measurements of vegetative and reproductive tiller heights and numbers were made at six-weekly intervals. In the first three months after transplanting seedling mortality was <7%. In contrast, tiller transplant mortality was much higher, particularly in the case of the Zululand ecotype tillers of which between 62-77% died at all three sites. At Umfolozi Game Reserve, seedlings grew most rapidly whereas at Cathedral Peak although seedlings of both ecotypes were comparatively small more vegetative tillers were produced than at Umfolozi. When considered together with reproductive data gathered and optimum seed germination temperatures for each ecotype the conclusion reached is that in Zululand ecotypes the contribution of seed production to maintenance of species position in the sward greatly exceeds that of Drakensberg ecotypes, which rely primarily on tiller production to remain in the sward.

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BURNEFFECT: an evaluation model for experimental burn treatments in grassland catchment areas

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The aim of applied ecological research is to improve ecological management. Constraints to improved management due to information gaps are caused by the absence of relevant information, or because such information has not been interpreted or synthesised into a form that is useful to management. This paper addresses the latter constraint. Grassland catchment areas are managed primarily to conserve water resources, for nature conservation, and to reduce fire hazard. Fire is the only practical means of manipulating biomass and species composition of large areas of grassland, and is consequently widely used to achieve the major aims. The Brotherton burning trial (situated in the Cathedral peak area of the Natal Drakensburg), was established in 1981 to assess the long-term effects of different seasons and frequencies of burning on plant species composition in grassland catchment areas. The model BURNEFFECT presents a methodology that synthesises and evaluates this burning trial data with in the context of specified management from objectives. Changes in plant frequencies caused by burn treatments are assessed using regression analysis data. Each burn treatment is scored according to a specified set of criteria. These criteria are assessed using indicator variables for each management objective. Possible burning management objectives for grassland catchments include reduction of fire risk hazard, maintaining biodiversity, improving water catchment and improving grazing potential of grasslands. The model BURNEFFECT has been developed using a windows spreadsheet environment. Input consists of a list of weighted management objectives. The model then uses a knowledge and data base to calculate burn treatment evaluation scores. Scores for grazing value are calculated using inherent grazing values of each grass species, the direction and probability of change caused by each burn treatment. Water catchment scores are calculated using the indicator variables of changes in frequencies of *Themeda triandra* and basal cover indexes. The effect of burn treatments on biodiversity conservation is scored by assessing the degree to which the burn results in a change in species composition. Relative fire risk hazard of each treatment is assessed by an index of the quantity and duration of biomass accumulation under each burn treatment. Burn treatments are assessed over a time period of ten years. Different management objective importance weightings can alter the type of burn prescribed. Sensitivity analysis of BURNEFFECT reveals the robustness of a particular burn option (i.e. by how much can management objective importance weighting change before the model will recommend an alternative burn option). The current version of BURNEFFECT reveals a biannual autumn burn to be the most robust (i.e. this option scores highest over the widest range of management objective importance ratings). The model BURNEFFECT emphasises the importance of prioritising

management objectives. It provides an objective assessment of the effects of different burn treatments scored against specified management objectives.

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The effect of variant levels of sodium chloride on the growth and development of *Cenchrus ciliaris*

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Soils are often found in nature which contain very high levels of salt. These soils are described as brackish soils and usually have a high pH. Soils with large quantities of sodium can also be described as brackish soils. Brackish soils usually develop in low lying areas or areas where salt accumulation can occur. High evaporation plays a major role and therefore brackish soils are relatively common in low rainfall areas. Due to the high salt content of the soil, the soil has a high osmotic potential which results in plants having difficulty in removing water from the soil. For this reason specially adapted plants occur in these areas. Certain nutrients are also inaccessible in brackish soils due to the high pH. Brackish soils with a high sodium content disperse easily due to the chemical reactions in the soil, which can lead to soil erosion. Although better management is preferable, the problem of saline soils may be circumvented if salt-tolerant plants can be used in these areas. Therefore screening procedures are necessary to select pasture plants which are best adapted to brackish soils. *Cenchrus ciliaris* is a very popular planted pasture in the drier and semi-arid parts of Southern Africa. The following screening technique was used to screen *Cenchrus ciliaris* at variant levels of NaCl. Seeds of different ecotypes and cultivars obtained from Australia, Tuscon, Pakistan, rest of Africa and locally were germinated on floats suspended in 5 L plastic buckets containing de-ionised water. Five days after sowing the de-ionised water was replaced with half strength Hoaglands nutrient solution. Following a further five days growth, NaCl was added to full strength Hoaglands nutrient solution in increments of 25 mM each day until the following increments had been set up: (1) 0 mM NaCl; (2) 50 mM NaCl; (3) 100 mM NaCl; (4) 200 mM NaCl; and (5) 300 mM NaCl. Plant height, number of tillers, leaves and root length were monitored weekly to determine plant growth. After 40 days the plants were harvested and the leaf area, fresh mass and dry mass of above ground and root components were determined.

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A vegetation model for Pilanesberg National Park, Bophuthatswana

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A vegetation model was developed which integrates vegetation classification and dynamics with faunal habitat suitabilities. The vegetation was surveyed with 295 plots placed systematically throughout the park. Woody species composition was recorded into four size classes: lower, middle, upper and emergent canopy. These SPIZE (species by size class) data were converted to cover abundance values per hectare using the following factors: 0.04 - lower canopy, 0.2 - middle, 0.6 - upper and 1.0 - emergents. These data were then subjected to ordination and classification. Each grouping of plots from TWINSPAN, was called a state. A descriptive guide for each state was produced, and this consisted of a photograph, a description of the state, woody SPIZE composition, grass species composition, and the state's habitat suitabilities for various herbivores. The grass species composition was visually determined and included in the description of the state. Year-round habitat suitabilities for a number of herbivores were established by using multiple operators to rate the suitability of each state, for each animal species. The states were mapped to produce a vegetation map, and from this, habitat suitability maps were also produced. An initial state-and-transition model was then developed, to explain to a manager how the vegetation can or cannot be changed from one state to another. This model was found to be useful in communicating vegetation research to managers.

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The accuracy of the fixed-point monitoring technique used to monitor grassland dynamics on the Blyderivierspoort Nature Reserve

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The Blyderivierspoort Nature Reserve forms part of the Drakensberg Mountains in the eastern Transvaal and is of importance as a water catchment area. One of the main objectives of the reserve is to manage the montane grassland in such a manner that a sustainable water resource is assured. The fixed-point monitoring technique has been used for the past three years, starting in 1991, to detect change in the species composition of the grass cover. The question however arose to what extent is the technique applicable for this reserve which hosts more than 220 grass species. Without doing a full scale project it was decided to repeat a few plots to determine the accuracy of the technique for this particular reserve. Acock's veld type 8 (North Eastern Mountain Sourveld), where the most problems with accurate identification occur, was chosen for the surveys. Grass species in this veld-type are very similar and much variation in comparable data was expected. Eight fixed-point plots (200 points per plot) were monitored for three repetitions and the data were compared. The repetitions were carried out using the same persons (three persons identifying), and also within the same month to reduce change due to plant growth. In 74% of the cases the difference between the lowest and highest count of a specific species was less than 11 observations, which means not more than 5% variation. In 53% of the cases the variation in species counts was less than 2.5%. In only 6% of the cases the difference in species counts were more than 10% which occurred mostly between the first and second repetition. It is possible that this is a result of misidentification at the beginning of the investigation. Even though the fixed-point method was not accurately tested in the form of a full scientific analysis, the results of this survey provide sufficient evidence to confirm that it can safely be used to make management decisions. This is also true if one considers the fact that decisions on specific management are area-based on the results of ten to twelve, 200-point plots in such an area. It also seems that knowledge of grasses is far more important than the technique itself and misinterpretation of veld condition results rather from identification and interpretation of ecological status of species.

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Response of *Cenchrus ciliaris* to moisture stress

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Forage production in southern Africa is often limited by a lack of moisture. Consequently improved forage plants must have the genetic resources that allow them to grow and survive in areas subjected to periodic water deficits. Until the fundamentals of drought resistance are more precisely defined, plant improvement programs will have to rely on screening procedures based on overall plant responses to drought stress. A selection of 39 *Cenchrus ciliaris* cultivars and ecotypes, obtained from Australia, Tuscon, Pakistan, rest of Africa and locally, were germinated in a greenhouse under controlled conditions (20°/30°C night/day temperature) in cone-shaped plastic containers filled with a sandy-loam/peat-moss mixture. After germination seedlings were reduced to one per container. Three weeks after sowing the cones were placed on trolleys in the greenhouse under a line source sprinkler system. Water was applied daily through a single spray nozzle situated centrally above the plants which moved backwards and forwards (timer controlled). Water was applied in a roughly triangular pattern with the maximum (150 mm per month) being received by plants directly under the nozzle. The amount of water applied decreased towards the edges of the trolley (27 mm per month). Long Ashton nutrient solution (5 ml of 200 mg L^{-1} N) was applied every second week. After ten weeks all plants were removed from the cones, the soil was washed away from the roots and the dry mass was determined of the above-ground and root components in order to monitor the root/ shoot ratios. The results obtained from the experiment were analyzed statistically and compared to field data.

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Festuca arundinacea on the Springbok Flats

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It was always believed that *Festuca arundinacea* was not well adapted to the warm northern Transvaal. On the other hand it was generally found that this grass establishes relatively easy on black clay soils on the Springbok Flats. Farmers started to use the grass under irrigation and it was decided to start with the National Fescue Cultivar Trial on Towoomba ADC. The following twelve cultivars were established on soil of the Arcadia form during March 1990: Fuego, Kentucky 31, Demeter, Falcon, Johnstone, Phyter, Festal, AU Triumph, Grasslands Roa, Barcel, Cajun and Arola. Fertilization during the 1991/1992 season (first season of production) included 550 kg N ha^{-1} and 275 kg K ha^{-1} while irrigation applied was 25 mm per week in summer and 15 mm in winter. During the 1992/1993 season 550 kg N ha^{-1} and 250 kg K ha^{-1} was applied and irrigation was the same as during the first season. The total rainfall was 423.7 mm for 1991/1992 and 491.4 mm for 1992/1993. During 1991/1992 the five best- producing cultivars were Festal (20.9 t ha^{-1}), Falcon (19.9 t ha^{-1}), Arola (19.3 t ha^{-1}), Grasslands Roa (19.1 t ha^{-1}) and AU Triumph (18.9 t ha^{-1}). The five best producers during 1991/1993 were Arola (16.3 t ha^{-1}), Festal (15.5 t ha^{-1}), Falcon (15.3 t ha^{-1}), Fuego (15.2 t ha^{-1}) and Kentucky 31 (14.6 t ha^{-1}). It therefore appears at this stage that the best adapted cultivars, after two seasons, are Arola, Falcon and Festal. The lowest producers during the second season were Johnstone (11.7 t ha^{-1}) and Barcel (11.7 t ha^{-1}). One of the advantages of tall fescue in this area is that it has no winter production depression, which is beneficial for fodder flow planning in the cooler bushveld areas. Farmers who traditionally planted annual ryegrass now use tall fescue as the only winter grazing in intensive fodder flow programmes. Tall fescue can be produced cheaper than rye grass due to the fact that it is a perennial. The fescue on Towoomba were grazed by sheep to evaluate preference rate of the different cultivars. Barcel seems to be the most palatable followed by AU Triumph and Johnstone. These preliminary results showed that tall fescue might be successfully incorporated in a fodder flow programme by farmers, with irrigation on the Springbok Flats, especially for sheep and dairy cattle.

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Species selection by goats at two stocking rates

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Goats were kept at two stocking rates (8 and 24 goats ha^{-1}) in savanna vegetation of the False Thornveld of the Eastern Cape. The average masses for the goats were 52.9 and 55.3 kg respectively, and they were kept in two 1-ha camps for 16 days in September 1993. The treatment with 8 goats ha^{-1} represented the recommended stocking rate for the area for three weeks. Feeding patterns of the goats were monitored through both vegetation and observations. Species selection and grazing intensity in the grass sward was monitored and preference of two evergreen and two deciduous browse species was observed. The grass species that were individually monitored to determine grazing intensity values were *Themeda triandra*, *Cymbopogon plurinodis* and *Sporobolus fimbriatus*. Grazing intensity values were given subjectively on marked tufts on a scale of 0 to 3. Grass species selection was determined twice weekly using randomly allocated transects in which species and presence/absence of visual signs of grazing was observed. Visual observations were done twice weekly, and goats were observed at four-minute intervals for grazing *vs* browsing, and when browsing, the species was also noted. *Themeda triandra* was the most-preferred grass species, followed by *C. plurinodis* and *S. fimbriatus* in both treatments. Although grazing was less selective in the high stocking rate than the low stocking rate, *T. triandra* was grazed significantly more-intensely in the former. There were no differences in either grazing intensity nor preference between *C. plurinodis* and *S. fimbriatus*. Goats were not deterred by the apparent unpalatability of *C. plurinodis*, as has been observed with cattle and sheep, even at the low stocking rate where animals would have had more opportunity to be selective due to lower grazing pressure. Browse selection was monitored by marking shoots of *Acacia karroo*, *Rhus lucida*, *Scutia myrtina* and *Grewia occidentalis*. *Scutia myrtina* was the most preferred browse species at both stocking rates, followed by

R. lucida, *G. occidentalis* and *A. karroo* in that order. All the observations on the vegetation and feeding behaviour of the goats were supported by observations. These phenomena could partly be explained by the low initial availability of feed in both treatments since this trial was carried out at the end of winter. Furthermore, many of the browse species are deciduous which limited the available browse. To conclude, goats are primarily browsers, but graze readily even when browse is not limiting. This is perhaps in an effort to ensure sufficient intake of dry material, since the browse is lower in dry matter content, and bite sizes possibly smaller. They also utilise a wider spectrum of grass species than other grazers. These factors make them highly efficient utilisers of vegetation, since they can readily adapt to changes, and utilise a broader range of herbage.

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Plant communities of the Messina Experimental Farm

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A sound knowledge of the ecology of an area is essential for an efficient wildlife management program. For this reason, and as a prerequisite for a study on the range utilization and habitat preferences by large herbivores, a floristic classification of the vegetation of the Messina Experimental Farm was undertaken. The study area covers 6 948 ha and is situated in the Limpopo Valley north of the Soutpansberg, South Africa. *Colophospermum mopane* is a conspicuous woody species in this area. The grass layer consists mainly of annual and weak perennial species. The mean annual rainfall is 353 mm and 75% of the total annual rainfall is recorded in the period November to March. January is the hottest month, with the mean daily temperature fluctuating between 21°C and 33°C. July is the coldest, with the temperature ranging between 7°C and 25°C. Extreme minimum and maximum temperatures recorded are -3°C and 44°C. By using 1:50 000 black and white stereo aerial photographs, the study area was stratified into relatively homogeneous physiographic-physiognomic units. Relevés were compiled for 149 sample plots, randomly located within these units and with a minimum of four sample plots per unit. Cover abundance values were estimated for all species in a 10 m x 20 m sample plot using the Braun-Blanquet cover-abundance scale. The vegetation was classified structurally and the predominantly structural classification is used in the name of the identified plant communities. Two-way-indicator-species analysis was applied to the floristic data set in order to derive a first approximation of the vegetation types. Refinement of this classification was done by means of Braun-Blanquet procedures. The results are presented in a phytosociological table. The analysis revealed seven major plant communities of which one is divided into two and another into three variations. The distribution of the different communities is shown in a vegetation map. The ten plant communities will provide the basis for a study on habitat selection by large herbivores and veld condition assessment of the habitats. The easily distinguishable major plant communities must be managed as separate ecological units in order to achieve optimal utilization and conservation of the vegetation.

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Lateral spread of *Acacia karroo* roots

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The lateral spread of *Acacia karroo* roots was investigated using a soluble marker. Eight grams of rubidium sulphate dissolved in 60 L of distilled water was placed in each of six strategically located 400 mm x 400 mm x 400 mm holes in early January. Holes were at least 100 m apart. Soil depth and type were mapped for the area. At the end of the growing season, before leaf drop occurred, twig and leaf material grown after placement of rubidium sulphate, were collected. Sampling was stratified according to tree size and direction and distance from the hole. Analysis for the presence of rubidium sulphate in the plant material was undertaken to determine the lateral spread of roots. The low concentrations and inconsistent increases of

rubidium in trees around the rubidium sulphate deposits limited the detection of lateral spread of *A. karroo* roots. From the results it is inferred that the roots of trees with trunk circumferences between 100 and 250 mm extend up to 15 m from the tree, while the roots of smaller trees, with trunk circumferences less than 5 cm extended up to 7 m from the trees. The root distribution of *A. karroo* trees appears extremely variable and localised since some large trees close to the rubidium source showed no rubidium increases while small trees up to 7 m from the source showed elevated rubidium levels. In the manner used, rubidium sulphate provided only a broad insight into root distributions of *A. karroo*. While this technique has great potential as a simple approach to detect root distributions of woody plants, investigations towards more efficient experimental procedures are required for improved results.

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The effect of the 1993/94 drought on veld production in the central parts of South Africa

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The current drought is generally considered to be one of the most severe droughts in human memory. The PUTU 11 simulation model was used to quantify the intensity of the drought. Geographically linked elements such as climate, soil characteristics and plant growth parameters were taken into account. The production potential of the area was determined by simulating veld production for each homogeneous area for a 30-year period. The drought intensity was computed by comparing the simulated production data of the current season to that of the long-term potential for each homogeneous area. With this technique it is also possible to predict production levels for the remaining season.

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The ordination of forage production data for forage planning and advisory purposes in the Highveld Region, South Africa

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Fodder flow planning is in great demand by livestock farmers in the Highveld Region. This demand is accommodated by using a computerized fodder planning programme. A large portion of fodder available on most farms is derived from cultivated pastures of which many are adapted to the region. It is the responsibility of the extension officers to recommend the cheapest adapted crop, suited to the individual needs, for each farmer. Some data, computer programmes and methods, which address this need, already exist. However, to ensure continuity, data must be organized and stored in computer databanks to speed up the fodder planning process. The additional programmes and databanks that must be created and linked to the fodder planning programme to facilitate acceleration include the following: (1) A databank which will allow the computer to make a crop choice after the following influencing factors have been taken into consideration: (a) climatic conditions; (b) soil conditions such as soil type, clay percentage and soil depth; and (c) livestock requirements; (2) Fodder production is influenced by many different factors, of which the main ones are: (a) type of crop; (b) soil potential category as defined by soil type, clay percentage and soil depth; (c) rainfall; and (d) nitrogen fertilization. In order to keep the fodder production databank uncomplicated only the four previously mentioned factors will be used to determine production. It will be assumed that all soil nutritional elements, barring nitrogen, are adequate. Production data are taken from existing data, scientific literature, farmers records, literature from work groups such the Co-ordinated Extension Committee, simulation programmes such as PUTU 11 and PUTU 13 as well as research. (3) A fertilization programme which will assist in the recommendation of the most economical type and rate of fertilization must be developed and also linked to the fodder planning programme. The crop choice, soil analysis as well as yield potential of a crop must be the

determining factors. (4) Finally, the total production costs of all the fodder sources must be calculated. These costs include machinery costs, such as fuel, servicing and repairs, as well as costs pertaining to seed, fertilizer, pesticides and herbicides. A programme which determines machinery costs already exists. Databanks which can determine the quantity of seed required plus the costs thereof, as well as the types, quantities plus costs of pesticides and herbicides required for specific problems, still have to be created. The fodder programme can then be linked to a livestock programme to determine the overall profitability of the livestock enterprises.

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Carbohydrate partitioning and the role of sugar fractions in the growth and production of lucerne cultivars

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Various studies have linked persistence of plant species to the efficiency of their carbon metabolism and reserve status. Non-structural carbohydrates can be accumulated and translocated to plant parts where they can readily be metabolized. Carbohydrate reserves are essential for survival and for production when carbohydrate utilization exceeds photosynthetic activity. Considering the importance of the carbon metabolism in plants, a study is proposed to investigate gas exchange efficiency and partitioned non-structural carbohydrate pools in lucerne (*Medicago sativa* L.) cultivars. Lucerne is a highly nutritious forage legume and information regarding its carbon budget will be used to determine if cultivars can be selected for specific uses on the basis of their ability to accumulate different carbohydrate fractions. The composition of accumulated carbohydrates in different lucerne cultivars will be analyzed with the use of high-performance liquid chromatography. Correlations between shifts in carbohydrate composition, cold and drought tolerance, as well as efficiency in regrowth after defoliation, will be investigated.

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Ryegrasses in South Africa

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In South Africa, the term ryegrass is frequently loosely employed to describe any one of the following: Italian and Westerwolds ryegrasses (*Lolium multiflorum*), collectively often referred to as annual ryegrass, perennial ryegrass (*L. perenne*), hybrid ryegrass (*L. perenne* x *L. multiflorum* derivatives) and festuloliums (fescue x ryegrass derivatives). The little-known *L. rigidum* is inscribed on the South African Variety List as "annual ryegrass" and should not be confused with *L. multiflorum*. Numerous ryegrass cultivars have been introduced into South Africa where they are usually grown under irrigation with high levels of fertility, often with clover. Ryegrass pastures are utilized for dairy, fat lamb and, to a limited extent, beef enterprises. A sound knowledge of the external stimuli that are involved in the induction of flowering in the different types of ryegrass is of considerable importance. Thus, most Italian, perennial and hybrid ryegrasses as well as the festuloliums require vernalization (an extended period of winter cold) in order to flower prolifically. In contrast, the Westerwolds ryegrasses and *L. rigidum* cultivars have no cold inductive requirement for flowering and will enter the reproductive phase in response to increasing daylength and/or temperature, even when sown in spring. From the foregoing it follows that in areas with mild winters, as for example the eastern Cape coastal areas, it is likely that following autumn establishment, the Italian, perennial and hybrid ryegrasses and the festuloliums will not become fully vernalised and will therefore not flower as prolifically as the Westerwolds-type cultivars. With the exception of true Westerwolds cultivars, seed production of these types should not be undertaken in areas where winters are mild. In autumn-sown trials conducted over three years and in which numerous Italian and Westerwolds cultivars were evaluated at various centres in South Africa, the Westerwolds cultivars were in general more productive than Italian ryegrass cultivars during the winter months while during the spring and early summer months the Italian cultivars were superior. A new development in recent years

has been the practice of oversowing ryegrasses into irrigable kikuyu pastures during the late autumn months, thereby improving the value of such pastures during winter and early spring. Spring-sown Italian ryegrass pastures, although extremely costly, persist for up to 16 months in some areas. Perennial ryegrass does not persist beyond two to three years in many parts of South Africa. Poor management, intolerance to high soil acidity and hot, dry summer weather patterns are the main contributory factors. Similarly, hybrid ryegrass cultivars, as for example Augusta and Bison, and festuloliums such as Felopa, have generally not persisted for more than two years in most areas. The *L. rigidum* cultivar Wimmera, an extreme annual type, was at one time used extensively in the western Cape. However, the outbreak of ryegrass poisoning in Wimmera pastures during the 1980's led to its banning.

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Timing of burns in the management of *Aristida junciformis* grasslands

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Grasslands in the mistbelt of Natal are dominated by *Aristida junciformis*, allegedly as a result of injudicious grazing management. In this paper we assess the effect of timing of burns on the species composition of this vegetation type, and we question the current burning dogma. Proportional species composition data from sites in this veld type which have been subjected to a variety of different burning, grazing and mowing treatments are ordinated and the relative distribution of sites in ordination space is related to management treatment. Sites which are burnt in the middle of the dormant season have the highest abundances of *Themeda triandra* and the lowest abundances of *A. junciformis*. We provide draft recommendations for burning management which need to be tested by further formal research.

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The influence of fire, boer goats and cattle on the woody component of the Sourish Mixed Bushveld

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The use of boer goats as browsers has been well documented by several researchers. Since it was proved that bush encroachment was one of the major factors that influenced carrying capacity of South African bushveld areas, the searchlight has again fallen on the use of goats as bush utilizers or bush controllers. Furthermore, the disuse of fire in this area is questioned, as the absence of fire is considered as one of the major reasons for the occurrence of bush encroachment. On the other hand, the disadvantages of both boer goats and fire have been well accepted by most farmers in the Transvaal Bushveld. The trial was conducted on Towoomba Agricultural Development Centre in the Sourish Mixed Bushveld. Eight camps were included in the trial. Three camps were rested for two years and burned during September 1988. They were again burnt during September 1990 after another two-year rest period. A goat-proof enclosure was erected in each of the three camps. The other five camps were left unburnt. The eight camps were subjected to the following grazing treatments, and the woody component alone was monitored during the 1990, 1991 and 1992 seasons: burn plus continuous grazing by boer goats; burn plus rotational grazing by boer goats; burn plus rotational grazing by cattle; burn plus no browsing or grazing (enclosures); no burn plus continuous grazing by boer goats; no burn plus rotational browsing by boer goats and grazing by cattle; no burn plus no browsing and no grazing; no burn plus rotational grazing by cattle; and no burn plus rotational browsing by boer goats. Decreases in evapotranspiration tree units, tree volume, leaf volume, leaf production and available browse were encountered in all camps where goats were involved. The effect was greater where fire was used in combination with browsers, continuous browsing causing the most damage to the existing woody component. In camps that involved only grazing, increases in all tree characteristics that were monitored were observed, the reaction being more severe where fire was used in combination with grazing. Bush density increased in all camps, but

to a greater extent where veld was burned. In the short term, bush could not be eradicated by fire or browsers alone. Browsers must therefore be used in combination with fire in the long term to give the desired level of bush control. In this sense the extreme importance of a well-planned after-care programme following burning is emphasized. As boer goats have a major role to play as bush controllers or bush utilizers in the Sourish Mixed Bushveld, it is believed that the potential of browsers in these areas is totally underestimated.

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The effect of nitrogen application and irrigation scheduling on ryegrass production

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One of the main factors affecting ryegrass yield is nitrogen application rate. Research has indicated that the nitrogen requirement of Italian ryegrass at high levels of irrigation varies between 350 and 450 kg N ha^{-1} a^{-1}. Water application also has a significant effect on ryegrass yield, but little is known about this effect, nor the nitrogen requirement of ryegrass at lower levels of irrigation and the effect of this on animal performance. This was investigated in a trial with two irrigation rates and four levels of nitrogen in a factorial design. The two irrigation treatments consisted of weekly irrigation to 80% of field water capacity and 50% of this value. The nitrogen treatments ranged from 100 to 400 kg N ha^{-1}. Results indicate that increasing nitrogen levels had a beneficial effect on animal performance while a decrease in irrigation application also resulted in improved animal performance.

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Quantification of the vigour of grasses in grazed veld

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The quantification grazing effects on grass vigour is important in understanding veld response to differential grazing management. Vigour can be determined by measuring regrowth during the season following grazing. Comparisons between measuring yield per tuft or quadrat and yield per unit tuft basal area of this regrowth revealed marked discrepancies between the methods. It is suggested that differences in vigour may in certain circumstances be reflected by a change in tuft size as well as amount of growth per unit tuft area. Quantification of residual effects of grazing on plant vigour should thus logically be done using techniques based on plant yields, either on an individual tuft basis or on a quadrat basis. Results based on measurement of yield per unit tuft basal area (and by association tiller or leaf based measurements) should be interpreted with care.

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A comparison between the production and utilisation of herbaceous species for different habitats in the north-western Transvaal Mixed Bushveld

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The Mixed Bushveld experienced a severe drought during the 1991/1992 season. Four habitats were chosen according to geology and soil differences. The veld in these habitats was in a relatively good condition in spite of the drought. The species composition of the herbaceous layer, as well as the production and utilisation of individual species was determined for each habitat. It was found that there is a close relationship between the habitat and vegetation type. In the sampling procedure, sub-habitats (under trees and between trees) were taken into account. The four different habitats were statistically compared in terms of production and utilisation of

the herbaceous layer. The aim was to determine the influence of habitat on production and utilisation of herbaceous species under the same climatic conditions. It was found that the clay content of the A-horizon of the soil in the study area had a profound influence on the production and utilisation of the herbaceous layer. Grazing capacity was determined for each habitat by using the production and utilisation values. This study is to be repeated over a period of time to determine the influence of both rainfall and habitat on the species composition and production and utilisation of the herbaceous layer.

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Variation in veld monitoring data obtained through multiple sampling of the same area

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Monitoring is today widely accepted as an important aspect of scientific range management. Natural veld is also considered to be a difficult natural resource to monitor because of the wide variation that occurs in time and space. It is also recognized that veld monitoring data obtained through simple standardized methods may be subject to significant human and statistical error. This occurrence may have dramatic practical implications for a veld manager who bases his management on changes detected through monitoring. If such changes are due to sampling error, and not as a result of real changes in the veld, serious management mistakes could be made. This experiment was launched to investigate the extent of variation in data under practical conditions. During 1992/1993 use was made of senior, well-instructed nature conservation students in executing several monitoring surveys. There surveys were done over a two-week period, in the same general area, during late summer. A standard 200-point, point-based technique was used. All surveys were personally supervised in an attempt to ensure that the technique was applied as accurately and as correctly as possible. Data on species composition and basal cover were obtained. The results show a disturbing variation in data! Possible reasons for this variation are discussed, as well as the practical implications of these findings for veld monitoring projects. The human factor definitely plays a major role in the accuracy of the data obtained, especially where different persons are involved. Certain measures can be applied in an attempt to minimize such errors in monitoring data.

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Root biomass of a dense stand of *Colophospermum mopane*

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The investigation was conducted during 1992 on an area north of the Soutpansberg, covered by dense stands of *Colophospermum mopane* and yielding no grass cover. In the middle of the site a hole was dug around a column (monolith) of soil and trimmed to an exact column of soil of 2.0 m x 0.5 m x 1.0 m (1 m^3). The soil of the monolith was removed in 5 layers of 200 mm. The roots were separated from the soil by hand washing, using fine-mesh sieves (0.5 mm^2). The roots of each soil layer were sorted into 4 classes (0-1.0 mm, >1.0-5.0 mm, >5.0-10.0 mm, >10.0 mm), dried to a constant mass (70°C) and weighed. The site had a tree density of 2 436 plants per hectare with a mean height of 2.7 m. Leaf dry mass of these trees was estimated at 1 445 kg ha^{-1} using a regression equation which relates spatial canopy volume (independent variable) to leaf dry mass (dependent variable):

$$\ln y = -4.165 + 0.711x$$

Total root biomass was a high 29 790 kg ha^{-1}. Fine roots (0-1.0 mm) were concentrated in the top 200 mm (2 980 kg ha^{-1}) with a linear decline with increased soil depth. The coarse roots (>100 mm) on the other hand displayed an increased concentration with soil depth up to a depth of 400-600 mm (5 420 kg ha^{-1}) whereafter they also declined.

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Agronomy of lupins for dry season forage in small-scale systems in Zimbabwe

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The potential of lupins to improve the supply of dry season grazing and to provide a protein-rich supplement to poor quality crop residues is being tested. Although lupins do have potential for large-scale irrigated systems, this research is focused on communal areas, vlei-margins, low-input situations. Three lupin species (*Lupinus* spp.) are being tested for adaptation to dry season production in Zimbabwe's agro-ecological (natural) regions (NR) II to V. Eight communal areas (two in each NR) are being used for on-farm trials in addition to on-station trials. Germplasm selection is based on tolerance to infertile, acidic, sandy soils (with or without residual fertility from a summer crop, but lupins not fertilized) and restricted moisture supplies (moisture largely residual). The effects on lupin growth of the following factors, which influence water availability, are under investigation : agro-ecological region, catenal position (vlei margin *vs* topland), vlei type (water storage capacity), planting date (February to May), and whether the land was cropped or fallow in the previous rainy season. The average summer rainfall is about 800 mm in NR II and about 500 mm in NR V. Pest and disease incidence is also being monitored. The germplasm under test is *L. angustifolius* cvs Danja and Gungurru, *L. albus* cvs Kiev and Wat, and *L. luteus* cv. Juno. An on-station trial in the dry season of 1992, under conditions of severe water limitations, showed that the *L. angustifolius* and *L. luteus* cultivars were better adapted than the *L. albus* cultivars. Consequently the latter were excluded from on-farm trials. Across the large number of communal area sites, *L. luteus* has proved more tolerant of acidic (pH 3.8 $CaCl_2$) and waterlogged conditions than *L. angustifolius*. Trials in NR II and III have given very encouraging results, whilst NR V, where there are no true vleis, has proved unsuitable for lupins. Useful information has been acquired concerning the effects of the other factors affecting water availability. *Lupinus angustifolius* cv. Gungurru and *L. luteus* cv. Juno did well on topland sites only when uncropped in the previous summer (crop fallow and grazing areas). When grown after a maize crop, with consequent excessive moisture depletion, lupins performed well only in vlei areas. True vleis showed no water limitation throughout the growing season. The February-planted crop suffered from waterlogging in vleis, whilst the May crop failed to establish on topland and at some vlei sites due to lack of surface moisture. Where maize was planted late (December/January) lupins planted in February and March were severely stressed on topland and poor vleis, except in NR II where the March planting was successful. Lupins planted when the maize was nearly at physiological maturity (i.e. early planted maize) gave better results. No serious pest or disease problems have been experienced, except for damping-off on a newly opened land which had a lot of organic matter, and there have been no signs of *Phomopsis* lesions. Dry matter yields obtained on-station in NR II were highest with March planting into a previously summer-fallow vlei area, and for *L. angustifolius*, *L. albus* and *L. luteus* were 3.4 , 2.3 and 6.6 t ha^{-1} respectively.

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The impact of elephant on miombo woodland in the Kasungu National Park, Malawi

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This paper reports on a study of the structure and species composition of the woody plants of *Brachystegia* woodland as a function of elephant (*Loxodonta africana*) densities. The study was conducted in the Kasungu National Park (12.92°S, 33.13°E) which is located on the Central African Plateau in Malawi at an altitude of approximately 1 000 m a.s.l. Mean annual rainfall is 820 mm and there is a single, summer, rainy season. The topography is gently undulating, drained by a network of seasonal marshy streams. Three treatment areas were differentiated according to a broad fertility status of soils and elephant densities. Treatment area A was characterised by infertile, sandy clay loam soils and a low elephant density. Treatment areas B and C corresponded to the distribution of ultrabasic rock intrusions resulting in ferruginous clay loam soils of higher fertility than treatment area A. Elephant densities in treatment areas A and C were classed as 'high' and

'medium' respectively. Treatment area C was divided into two sub-areas to account for wood cutting (for domestic use) activities on a portion of the treatment area. Vegetation surveys were conducted on the woody component of each treatment using a systematic point-sampling procedure. Species composition, plant density, and the proportion of plants browsed by elephant, or cut, was determined for each of four height classes (viz. <0.5 m, 0.5-1.5 m, 1.5-3.0 m, and >3.0 m). Pattern seeking, ordination analyses were conducted on the floristic data for each height class. There appears to be a relation between elephant densities and floristic composition of woody plants in the < 0.5 m, 0.5-1.5 m and >3.0 m height classes. There is also a general decline in tree density in the <0.5 m, 0.5-1.5 m and >3.0 m height classes with increased elephant density.

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Training rural communities in the use of the key species method for the assessment of range condition

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A key species method for the assessment of range condition has been developed for the Ciskei region. Training in the use of this method is currently being given to extension officers and farmers in rural communities. Sixty participants have undergone training and have reacted positively and asked for further training. It is also apparent that the courses must be given at different levels. The present technique is aimed at extension officers and other planning officials that have some tertiary training but a different approach needs to be adopted for the farmers. Problems that have been encountered during the courses include, the lack of arithmetic skills amongst participants, the need for common names of plants and the need for practical and appropriate range management recommendations. Principles of range management should be taught rather than rigid range management practices. Possible solutions include, visual aids for range management concepts (e.g. stocking rate should be represented as 1 cow in six soccer fields, because an animal unit and a hectare are foreign concepts), and a technique that has minimal or preferably no arithmetic calculations.

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Root development of *Lolium perenne* L. as influenced by grazing management

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An experiment was conducted to examine the effects of sheep grazing on the root production and development of a newly established *Lolium perenne* (perennial ryegrass) pasture. The trial was established in September 1992 at the University of Natal's research farm, Ukulinga. All treatments received equal fertilizer (40 kg N ha^{-1} per month) and irrigation (25 mm per week). Root data, collected using a 100 mm diameter soil corer to a depth of 200 mm, are compared for six grazing treatments. These grazing treatments included various combinations of grazing frequency (HF, MF and LF = high, medium and low frequency, respectively) and grazing intensity (HI, MI and LI = high, medium and low intensity, respectively), applied as rotational grazing. A continuous grazing system (CG) was also applied. Each of these treatments was replicated four times in a randomized blocks design. Sampling was conducted during November 1992, April 1993 and September 1993. Four randomly placed core samples were taken per plot (i.e. 16 samples per treatment). The design of the experiment allowed comparisons of root dry matter production in four soil depth profiles: 0-50 mm, 50-100 mm, 100-200 mm and 0-200 mm. These data were analyzed by means of analysis of variance. For the November data, root dry matter per unit volume for the 0-200 mm soil depth ranged from 0.537 (MFMI) to 0.676 g per 1 000 cm^3 (LFHI). There were no significant treatment effects for any of the individual depth profiles analyzed ($P>0.05$). At the April sampling, total root dry matter for the 0-200 mm depth had increased to between 0.705 (MFMI) and 1.060 g per 1 000 cm^3 (HFHI). Over this rooting depth, HFHI had a significantly greater root mass than LFHI, MFMI, LFLI and CG. The data also suggest that grazing had affected the depth at which roots were distributed in the soil profile. The LFHI treatment, for

example, possessed a greater root mass in the 100-200 mm soil depth stratum than a number of the other treatments. The September root data revealed no significant treatment effects over the four depth profiles ($P>0.05$). Total root dry matter, for the 0-200 mm depth had increased to between 1.630 (MFMI) and 1.948 g per 1 000 cm^3 (LFLI) at this sampling. Interestingly, all treatments showed a significant increase in total root dry matter (for the 0-200 mm depth) from November to September ($P<0.05$). It would, therefore, appear that the root system continued to expand throughout the post establishment year.

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An evaluation of the oesophageal fistula valve technique

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Oesophageal fistula samples have been accepted as more indicative of the true diet of grazing and browsing animals than forage and/or browse sampled by other methods. On the other hand,due to limitations imposed by the oesophageal fistula technique on the grazing area sampled and the number of samples that can be collected per day,the reliability of this technique to reflect the total daily feeding period has been questioned. Furthermore the limitations imposed by this technique are of particular importance where browsing animals are being studied in extensive areas having heterogenous plant communities. An obvious solution to these limitations would be to collect a sufficient number of small samples throughout the day in order to adequately represent the total daily feeding period in terms of both time of the day and species selected. Based on this thesis, a remote-controlled system for the collection of multiple extrusa samples in goats was developed at the University of Fort Hare. The prototype oesophageal fistula valve was however,only tested on a limited number of goats and range of samples. The objective of this study was to further evaluate the oesophageal fistula valve technique using six Boer goat ewes at two different stocking rates (8 and 24 goats per hectare). The limited problems experienced during sampling were valve blockages and wire breakages between the battery pack and the valve servo motor.

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A study of herbaceous layer production in savanna areas of the eastern Transvaal Lowveld

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The study forms part of an ongoing vegetation monitoring programme in the eastern Transvaal lowveld. Preliminary findings of two consecutive seasons' data for the Klaserie and Sabi Sand Private Nature Reserves are compared. A double estimation technique was used in conjunction with actual clippings to quantify the herbaceous biomass. This method proved to be quick and efficient when surveying many sites distributed over the large study area. The survey area includes mesic (mean annual rainfall of approximately 600 mm a^{-1}) and semi-arid (mean annual rainfall of approximately 400 mm a^{-1}) savannas. By measuring residual biomass (standing crop) at the end of the growth season, herbaceous layer production was calculated for 202 sites. Herbaceous biomass values were correlated with the three dominant species for each site and a list of important species in terms of herbaceous production is presented. Production values obtained, in conjunction with herbaceous composition analyses for each site, facilitate a greater degree of reliability when proposing appropriate management practices (e.g. stocking rates) for wildlife areas.

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Lupin supplementation for pregnant ewes on winter veld at Nooitgedacht A.D.C.

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During 1992, the effect of seven levels of lupin grain supplementation on pregnant merino ewes grazing rested winter veld was evaluated with a fishmeal supplement as control. Results indicated that pregnant ewes can locally be successfully wintered on rested veld with sufficient lupin grain supplementation. Daily supplementation rates of 150 g during early and mid pregnancy, and 250 g during late pregnancy proved to be sufficient. At this supplementation level ewe body mass, lamb birth mass and preweaning lamb growth was satisfactory. Associated supplementation costs were 10 cents per ewe per day, which can be regarded as very cheap. Rested veld could thus play an important role as cheap feed source during winter in local fodder flow programmes.

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Influence of woody plant density on coppice growth in the Lowveld of Natal

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Increasing woody plant densities result in elevated competition for available resources by the woody components of savannas. Competitive release following bush thinning favours untreated individuals, which are then able to utilize resources which were previously unavailable to them. Thinning density will have an effect on competitive interactions between treated plants and remaining individuals. In this paper we assess the effect of thinning density on the recovery of treated woody plants in the Lowveld of Natal three years post-treatment. We provide preliminary recommendations for bush thinning to maximize grass and browse production.

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Influence of woody plant density on herbaceous production in the Lowveld of Natal

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Increasing woody plant density as a result of bush encroachment is negatively correlated with herbaceous production in savannas. Competitive release following reduction of woody densities results in increased production by the herbaceous layer. In this paper we present replicated herbaceous production data over two seasons on a bush thinning trial consisting of 12 treatments. Further, we compare these data to herbaceous production over one season on an area where bush was controlled mechanically. From these results, we make preliminary recommendations for bush control on cattle ranches.

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Agronomic evaluation of ten cultivated grasses

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The trial was located in Maputo Province, Mozambique in deep, sandy soils, 33°E, 26°S and 24 m elevation. Rainfall during the establishing growing season was 791 mm, during the first harvest year 430 mm, and during the second year 707 mm. *Cenchrus ciliaris* cv. Gayndah, *C. ciliaris* cv. Biloela, *Chloris gayana* cv. Katambora, *Cynodon dactylon* cv. Tifton 85, *Panicum coloratum* cv. Bambatsi, *Andropogon gayanus* cv.

Gamba, *Eragrostis curvula, Cynodon dactylon* cv. Couch, *Panicum maximum* (local), and *Urochloa mossambicensis* (local) were seeded in 4.4 m x 4.4 m plots and allowed to establish for one rainy season. A 300 kg NPK fertilization split into two semi-annual applications and an unfertilized control were imposed on sub-plots. Bi-monthly (2M) and twice-annually (6M) harvests were imposed on sub-sub-plots and season (May-October for dry season, November-April for rainy season) totals were calculated. Dry matter (DM) production and crude protein (CP, unreplicated) percentages were determined. There were no significant interactions amongst the three factors for either season. Rainy season averages showed a difference ($P<0.001$) among entries with Katambora, Biloela and Gayndah showing the highest DM values. Average rainy season values showed a difference ($P=0.023$) between cutting regimes with 2M cuts producing 77% of the 6M harvest and 92% higher CP percentages. NPK application produced a 22% increase in DM and 12% increase in CP. Dry season averages also showed a difference ($P<0.001$) among entries with the same entries at the top. No difference ($P=0.31$) appeared between cutting regime DM productions although CP percentage was 40% higher in the 2M treatment. Fertilizer application produced a 36% increase in DM and 2% increase in CP. This study indicated that Katambora, Gayndah and Biloela were the most productive entries although the two locally collected grasses had the highest CP values. The 2M harvest produced less DM in the rainy seasons but the quality of what was produced was higher as indicated by the nearly doubling of the CP value. Economic considerations may annul the value of the NPK application which increased DM production by 25% and CP% by 6%.

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The effect of fire and combinations of fire and grazing on the meristematic potential of *Themeda triandra* in Sourish Mixed Bushveld

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Although fire and grazing are the principal veld management tools available to pastoralists, little is known about plant responses to their separate and combined influences. When active meristematic tissue is removed, the re-establishment of a new photosynthetic canopy is dependant on the initiation of new tillers. Therefore the absence of active meristems will be a major constraint on the ability of a grass to tolerate herbivory. The effect of fire and/or grazing on meristematic potential, and therefore on plant vigour will be investigated by making several observations. The trial which has been set up at Roodeplaat covers an area of 14 ha, and is situated in the Sourish Mixed Bushveld at 25°30'S, 28°20'E. There are six treatments, with four replicates of each treatment, each replicate covering an area of 64 m^2. The six treatments are as follows: annual burning with grazing; annual burning with no grazing; biennial burning with grazing; biennial burning with no grazing; quadrennial burning with grazing; quadrennial burning with no grazing. The objectives of the study are to (1) determine the effect of different patterns of defoliation on tiller initiation and tillering habit; (2) determine the effect of different patterns of defoliation on the reproductive potential of *Themeda triandra*; (3) investigate the relation between defoliation and the position of meristems, and the influence this has on the architecture and eventually survival of the plant; and (4) determine the specific locations of initiated tillers on the parent. Destructive and non-destructive sampling methods will be used. With destructive sampling, tillers will be used as the basic sampling unit. Two tillers per treatment (i.e. 12 per replicate) will be harvested monthly and the following observations will be made: number of axillary buds; position of axillary buds; viability of axillary buds; height of developing buds; size of developing buds; condition of the apex; and the height of the apex. Non-destructive sampling will involve the whole tussock, in which the same tussock will be monitored throughout the whole period. The following observations will be made: diameter of the tussock; the position of new tillers within the tussock; the angle at which the tillers on the periphery emerge; and the ratio between the number of vegetative tillers and reproductive culms. Preliminary results will discussed.

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Alternative irrigated winter pastures for lactating ewes in the south-eastern Transvaal

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Italian ryegrass is the most important irrigated pasture in the south-eastern Transvaal. High nitrogen and annual establishment costs associated with Italian ryegrass production, led to the investigation of alternative irrigated pastures for utilisation by lactating ewes at Nooitgedacht ADC. Pastures evaluated included Italian ryegrass, arrowleaf clover, a mixture of annual ryegrass and arrowleaf clover and a perennial fescue/white clover mixture. Carrying capacity on the pure ryegrass and fescue/white clover pastures was 30 ewes with lambs per hectare. On the arrowleaf/ryegrass mixture the carrying capacity was relatively low (22 ewes with lambs per hectare). Ewe and lamb performance in all the pastures was very good with pre-weaning average daily gains of over 250 g d^{-1} for lambs. The perennial fescue/white clover mixture appears to be the most promising economically.

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The production of compounds affecting the quality of forage

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In spite of the considerable economic importance of grasses, this family has yet to be thoroughly surveyed for its flavonoid and phenolic constituents. Detailed chemical studies have been mainly limited to cultivated species (e.g. *Sorghum* and *Triticum*), but even here our knowledge is still relatively superficial. Knowledge of the phenolic constituents of grasses, and other forage and browse species, is of practical importance when assessing nutritional status. This is due to the protein-complexing ability of flavonoids. Such interactions occurring in fodder or silage may reduce the nutritional value and therefore have a negative affect on animal performance. Of 1 104 grass species belonging to 290 genera, 39 genera and 101 species of grasses from southern Africa were reported to contain visually discernable tannin-like substances in the epidermal cells of the leaf blade. The presence of condensed tannin in one of these species, *Eulalia villosa* was recently confirmed. The presence of condensed tannin in southern African grasses may be ecologically significant in terms of herbivory. Further investigation is therefore essential to determine the presence and effects of tannin, and other secondary compounds, on the quality of forage in relation to animal performance. The aim of the project is to gain a better understanding of the driving force behind the production of secondary compounds, in order to improve or adapt management practices in relation to improved animal production. The generally accepted resource availability hypothesis is based on the assumption that forage quality is correlated to its protein quantity and thus reflects the carbon to nitrogen balance of the plant. Forage quality is recognised to have several correlates, including fibre content and *in vitro* digestibility. Although the hypothesis is based on nitrogen as key nutrient, it can be applied to other organically bound nutrients. The resource availability hypothesis in relation to secondary compound production will be tested under controlled environment conditions. The project will consist of two phases extending over two growing seasons. In the first phase a sub-tropical grass species known to contain tannin, *Eulalia villosa*, will be used to test the hypothesis under conditions of drought. The plants will be harvested on a monthly basis and the following factors determined: total non-structural carbohydrates, crude protein content, neutral detergent fibre, *in vitro* organic matter digestibility and tannin content. It will be aimed to determine possible correlations between the various quality factors and secondary compound production such as tannin. If correlations are evident, a number of grass species will be surveyed under different environmental conditions in the second phase of the project. Understanding the mechanisms controlling the production of secondary compounds could contribute to the development of management strategies to improve forage quality.

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When to burn Döhne Sourveld?

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Monthly burning treatments were applied from mid-July to mid-November in three replications for four consecutive seasons. No grazing was applied to the treatments. Herbage yield, species composition and the amount and time of rain were recorded. During the first two seasons, additional parameters recorded were environmental conditions at the time of burning, fuel load, fire intensity and tiller mortality after the fire. Time of burning during the winter/spring period showed no effect on species composition but late burning (November) was associated with lower herbage yields. Depressed yields appear to result from a reduced growing period rather than an effect of burning *per se*. Burning after the first spring rains was considerably cooler than burning before the rain. Although there were major differences in tiller mortalities between *Themeda triandra* and *Tristachya leucothrix*, time of burning had very little effect on tiller mortality within species. It is concluded that the timing of winter/spring burning to remove moribund, unpalatable material is not of major concern but that burning immediately after spring rain should be the preferred time of burning.

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A basis for the physical management of Rustenburg Nature Reserve

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A generally accepted principle is that the smaller an area, the more intensively it must be managed, as such areas are not self-regulating ecological units. The primary objective of the Rustenburg Nature Reserve, which covers an area of only 4 250 ha, is the conservation and maintenance of the biotic diversity associated with the unique marshland on the crest of the Magaliesberg. A need for intensive physical management of the reserve lead to an investigation to develop a basis that could be used as a guideline for planning burning blocks, fire breaks, placement of licks, etc. It also serves as a basis for monitoring veld condition and game movements. A soil map, together with other important management components such as geology, vegetation and physiographic features, was used to differentiate seven management units which are relatively homogeneous in terms of its ecology and response to management and utilization. Only the major soil differences like texture, depth and geological origin were taken into account. Suffice it to say that the practical implementation of this basis also determines the final borders of the different units, which results in some measure of heterogeneity in the units. The main characteristics of the seven units are as follows. RHM1: Deep, red soils which vary from sandy clay on the concave slopes to sandy loam on the convex slopes, dense *Acacia caffra-Rhus pyroides-Diospyros lycioides* woodland. RHM2: Deep, red soils with a sandclayloam texture, long grassland with open *Burkea africana-Protea caffra* savanna, herbaceous layer dominated by *Trachypogon spicatus*, *Diheteropogon amplectens* and *Themeda triandra*. Also important in this unit is the *Protea caffra* community on the plateau, with very similar characteristics. RHM3: Pediments in the low-lying valleys on the north-eastern slopes of the mountain, underlain by relatively young soils, mainly alluvial, deep sandloam to sandclayloam texture, originate from a diabase intrusion, vegetation dominated by broadleaved deciduous trees and *Acacia caffra* woodland. RHM4: Very shallow soils, underlain by quartzite, A-horizon with a very high organic content, medium grassland dominated by *Loudetia simplex*, *Eragrostis nindensis* and *Themeda triandra*. Well-utilized by selective grazers such as red hartebeest and springbok. RHM5: Very shallow soils, A-horizon almost non-existent, vegetation dominated by *Bequartiodendron-Landolphia-Rhus magalismontanum* shrubland. Herbaceous layer only exist as species from the family Cyperaceae. RHM6: Medium deep to deep soils of the Glenrosa-form on a southern slope, poorly utilized, vegetation consists of open *Faurea saligna-Acacia caffra* savanna. RHM7: Marshland on the crest of the Magaliesberg, deep, rich soils, very high organic content with a melanic A-horizon, vegetation dominated by *Phragmites mauritianus* and *Pteridium aquilium*. The seven units differ as far as certain soil properties, vegetation structure and composition and primary production is concerned, and are currently used for the physical management of the reserve. It should be stressed that these units are dynamic and boundaries could change if the situation necessitates a change thereof.

Athole farming systems

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The development and promotion of viable and practical farming systems for the eastern Transvaal highveld based on the principles of optimum resource utilisation, biological feasibility, sustainability and economic efficiency has been undertaken at Athole Research Station. This takes the form of six systems trials carried out on a mini-farm scale. These systems range from having sheep as the sole livestock enterprise with lambing seasons ranging from early autumn, late autumn and spring, to sheep and cattle together, and an intensive sheep system. All the systems include crop enterprises. Additional variables included are differing winter feed sources for cattle and differing veld management strategies for the livestock enterprises. The results from these systems are used to complement component research results in developing information packages covering the various farming enterprises. These farming systems also play an important role in problem solving, problem identification, evaluation of component research, model calibration and are invaluable for extension and demonstration purposes.

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Evaluation of perennial grasses under dryland conditions in the Boland and Outeniqua areas of the south-western Cape

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The incorporation of a suitable grass into the traditional legume pasture in the winter rainfall region of South Africa could ensure a higher production during the winter months and reduce invasion by grass weeds. In the search for suitable grasses, 23 cultivars (four different species - *Phalaris aquatica, Dactylis glomerata, Bromus willdenowii, Festuca arundinacea*) were evaluated in small plot cutting trials over three seasons at Elsenburg (near Stellenbosch, Hutton soil form, long-term annual rainfall of 606 mm) and Outeniqua (near George, Estcourt soil form, long-term annual rainfall of 694 mm.) Research Stations. Although, the tall fescue cultivars (*F. arundinacea*) were generally high yielding, the results clearly indicated a difference in adaptation of the cultivars to the different ecological regions. Cultivars such as Siro Seedmaster (*P. aquatica*) and Currie (*D. glomerata*) were better adapted to the strictly Mediterranean climate of Elsenburg, than the all year rainfall of Outeniqua. The exception to the rule was AU Triumph which performed equally well at both sites.

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Evaluation of annual ryegrasses under dryland conditions in the Boland and Outeniqua areas of the south-western Cape

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Since its release in 1975, Midmar, a diploid predominantly Westerwolds type of *Lolium multiflorum*, has been the most popular cultivar in South Africa. Consequently Midmar is generally accepted as the norm against which newly introduced cultivars, as well as locally-bred lines, should be evaluated. The purpose of this experiment was to assess the potential yield of a number of ryegrass cultivars in two different ecological areas of the winter rainfall region of South Africa. Midmar and 15 other annual ryegrasses were evaluated during the season of 1991/1992 in small plot cutting trials at Outeniqua (Estcourt soil form, long-term annual rainfall of 694 mm) and Elsenburg (Hutton soil form, long-term annual rainfall of 606 mm) Research Stations. At Outeniqua the predominantly Italian-type ryegrasses generally performed well and, with the exception of Serenade, all the cultivars had above average dry matter yields. This might be attributed to their longer growing season, which enabled them to make better use of the long wet season at this site. However, Westerwolds types such as Energa and Vitesse also did extremely well. In fact, Energa was the highest

producing cultivar with a dry matter yield of 16.16 t ha^{-1}. Midmar also did rather well. The dry matter production obtained at Elsenburg was very low. This might be attributed to the very cold winter and spring months and the rather short growing season. As in previous trials, the predominantly Westerwolds types were generally high producing at this site. The highest yielding cultivars (dry matter yield >4 t ha^{-1}) were Jackson, Marshall, Apollo 46, Florida 80 and Midmar, all Westerwolds. The only exception was Turtetra, an Italian ryegrass, which also performed well.

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Evaluation of serradella in the Hopefield district of the Swartland

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Annual *Medicago* species (medics) do well in most areas of the Swartland, but they do not thrive in the sandy soils along the West Coast of South Africa. Pink serradella (*Ornithopus sativus*) has traditionally been cultivated on these sandy soils, but yellow serradella (*O. compressus*) appears to be a more suitable candidate, as it is more hard-seeded than pink serradella. Yellow serradella, like medics, always leaves a bank of ungerminated seed in the soil after regeneration. This obviates the need to resow every season. Eight yellow serradella cultivars (Pitman, Uniserra and Eneabba - two chemically induced mutants of Pitman, Tauro, Avila, Madeira, Elgara and Paros) and one pink serradella were evaluated over three seasons (1991-1992) under dryland conditions in small plot cutting trials near Hopefield (Fernwood soil type, long-term average rainfall of 394 mm a^{-1}). Pink serradella cv. Emena was the highest-yielding during the first season, but it produced significantly less seed and was consequently lower yielding during the subsequent seasons. The rainfall distribution had a pronounced influence on the dry matter production of the yellow serradella cultivars. The early flowering cultivars did well in the first season, but the late flowering cultivars performed better in the second season due to good spring rains. It seems to be advisable for farmers to use a mixture of pink and yellow serradella. Pink serradella will ensure a good stand in the first year, while the yellow serradella gradually becomes more dominant in subsequent seasons.

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Evaluation of fourteen annual medics in the Boland area of the western Cape

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Annual *Medicago* species (medics) originating from the mediterranean basin in Europe and North Africa, are well adapted to the winter rainfall region of South Africa. They are, apart from lucerne (*M. sativa*) the most important dryland pasture legumes in this region. They also play an important role as ley crops in the maintenance of soil fertility in the wheat producing areas. Although, the majority of the cultivars used by farmers are of species *M. truncatula* and *M. littoralis*, alternative species are currently being investigated for better production and pest resistance. Fourteen medics cultivars/lines of five different species, viz. *M. polymorpha, M. truncatula, M. littoralis, M. murex* and *M. aculeata* were evaluated over three seasons (1990-1992) in small plot cutting trials at Elsenburg Research Station (Hutton soil form, mean rainfall 606 mm a^{-1}). The length of the rainy season had a pronounced influence on the performance of the cultivars. The rather short rainy season of the first year (1990) favoured the earlier flowering cultivars. In the subsequent seasons the later flowering cultivars and *M. aculeata* lines did well.

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Seasonal production of annual ryegrasses under irrigation in the Outeniqua area of the southern Cape

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In the main milk-producing areas of the southern Cape, *Lolium multiflorum* is considered one of the most important temperate grass species, owing to its relatively superior winter yielding capacity. Although, total dry matter production is considered to be an important criterion in evaluating the relative performance of different cultivars, the seasonal dry matter production is exceedingly valuable for fodder flow planning. Dry matter production of nine *L. multiflorum* cultivars, sown in May, were obtained over a two-year period at Outeniqua Research Station (Estcourt soil form) under a five-weekly cutting regime. The production curves of the primarily Italian types were different from the Westerwold types. There was, however, very little difference between the cultivars within each of the two groups. The Westerwold types were generally higher yielding than the primarily Italian types, during the first three months. The Italian types had, however, generally a longer growing season than the Westerwold types and thus a higher total dry matter production, especially in the second year.

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The effect of different defoliation treatments on the production and short-term persistence of *Leucaena leucocephala* accessions

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The manner and degree of defoliation by different grazing animals differs from that achieved by cutting. Persistence of grazed legumes can also be affected by the treading, excretion and seed dispersal components of the grazing process. The objective of the study was to evaluate the effect of different defoliation treatments on the production and persistence of different *Leucaena leucocephala* accessions. The criterion in this study was the expression of high yield over a number of years. Two experiments were conducted, one at Pretoria and the other at Nelspruit. The accessions included were BRA 000752, BRA 000761 and BRA 000728 at Pretoria and BRA 000701, BRA 000779 and BRA 000761 at Nelspruit. These accessions were selected on the basis of results obtained in production trials prior to this study. The defoliation treatments at Pretoria consisted of a cutting treatment as well as browsing treatments by Pedi sheep, naturalised goats and cattle. At Nelspruit only two defoliating treatments were applied, namely a cutting and browsing treatment by cattle. A strip split-plot was used at both sites. The gross plots consisted of defoliation treatments and the sub-plots consisted of different accessions. The period of browsing was restricted to not more than four days which minimized repeated browsing. The first treatments were applied when the height of plants was 1.0-1.5 while the consecutive treatments were applied when the plants had enough material for four days of browsing. The *Leucaena* plants were browsed until *c.* 95% of the edible material was utilised in a treatment. The treatments were applied in two consecutive seasons. In both trials, the cutting treatments produced significantly less edible material than the browse treatments. The treatments which were defoliated by cutting, visually tended to have a higher percentage leaf. However these treatments produced less edible material in a season than those browsed, because they had to produce new leaves as well as new stems. Regarding the respective browsing treatments applied at Pretoria, it appeared that cattle had a more severe impact on *Leucaena*. This may have been caused by heavier treading and utilisation of thick stems up to 6 mm in diameter. In both trials the interaction between defoliation treatment and accession was not significant. The differences between accessions were small and indicated that BRA 000728 and BRA 000761 were suitable for application at Roodeplaat. At Nelspruit BRA 000761 and BRA 000701 produced the highest yield. Plants browsed by sheep and goats grew rapidly beyond the reach of animals during the season and became more tree-like. This reaction by *Leucaena* to defoliation by small stock was more pronounced in the case of sheep since they can not reach growth points as high as goats. To keep *Leucaena* within browsing height, especially for goats and sheep, it will be necessary to cut the material mechanically at least once a year.

Soil-vegetation associations in the eastern Transvaal Lowveld

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Soil analysis was done on 40 transect sites in the Klaserie Private Nature Reserve and the Sabi Sand Wildtuin. The geology was examined, soil profile pits were excavated to a depth of 1.5 m and soil samples were taken from the soil horizons at each site. The sites form part of a veld monitoring project, where, among others, herbaceous composition and production are measured annually. Relations between soil types and vegetation communities are highlighted and correlations between the two are presented.

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The concept of grazer and browser animal units for African savanna areas

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The large stock unit (LSU) is commonly used to express stocking rates, but provides only a measure of the grazer stocking rate. The feeding patterns and digestive systems of grazers and browsers differ, rendering the LSU less valid for browsers. An objective method to express grazer and browser stocking rates is proposed to allow the practitioner to express stocking rate in terms with which he is comfortable. Discretion is obviously required to further divide the animals into feeding and habitat preference classes. Grazers and browsers are defined as exclusively grazing and browsing animals of 450 and 140 kg respectively. Grazer animal unit (GAU) and browser animal unit (BAU) replacement values may be calculated for herbivores using the hypothesised diet of the animal, its metabolic mass, and a reference norm of 450 and 140 kg respectively.

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Rangeland composition and "The Fence": the current situation in western Kruger National Park and adjacent private nature reserves

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In terms of management, the dropping of the western boundary fence of the Kruger National Park has important implications as regards the management of the extended system. The woody and herbaceous layers were measured in the area of the western boundary of the Kruger National Park and the eastern parts of Sabi Sand, Timbavati, Umbatat and Klaserie. The results presented give an idea of the situation as regards the state of the vegetation before removal of the fence under different management regimes. This type of research will help us to better understand the functioning of savanna ecosystems in the eastern Transvaal Lowveld. This in turn will provide us with the tools to manage these areas more effectively.

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The effect of different winter utilization periods on *Digitaria eriantha* foggage on the growth of weaners: preliminary results

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The investigation was carried out on established *Digitaria eriantha* pastures situated at Potchefstroom which is in the Highveld Region. Thirty-two hectares of *Digitaria eriantha* pasture was fertilized during the spring at a rate of 80 kg N and 8 kg P ha^{-1}. The pasture was subdivided into two treatments - harvested and

unharvested. Due to insufficient rainfall (471.2 mm) the harvested pasture could not be grazed. Subsequently the 16 ha unharvested pasture was utilized during two periods namely early winter and late winter. Four paddocks of 2 ha each were allocated for each utilization period. Twenty-eight Simmentaler weaners were allocated to each of the utilization periods. The Simmentalers were weaned before commencement of the trial and were allocated to a separate camp for the adaptation period. A loss in mass occurred which they were not able to regain within a week and therefore a minimum adaptation period of two weeks is recommended. The crude protein and *in vitro* dry matter digestibility (IVDMD) decreased from 5% crude protein with an (IVDMD) of 49%, at the beginning, to 3% crude protein with an (IVDMD) of 28% at the end of the trial. The Potchefstroom lick, which consists of 22% urea, 22% di-calcium phosphate, 22% maize meal and 33% salt, was given *ad lib*. The average daily intake ($P \leq 0.05$) was 104 g d^{-1} during the first and 176 g d^{-1} during the second utilization period. From the results obtained no significant ($P \leq 0.05$) increase in mass change between the two utilization periods for the unharvested pasture was observed. Grazing capacity was 3.5 ha LSU^{-1} with an ADG of 0.13 g d^{-1} and losses due to trampling were 33%. Pasture fertilization, at the reported level of rainfall (471.2 mm), during the growing seasons was not profitable in accordance with the average annual production of 2.3 tons for hay.

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Bush clearing: the effect of two arboricides on *Rhigozum trichotomum* and the associated grass layer on different soil types in the Kalahari dune veld

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The study was conducted on two different soil types (red Kalahari sand on the dunes and white Kalahari sand in the dune streets) on the "Massakloutjie" demonstration farm in the Kalahari dune veld. Both plots were covered by a homogeneous stand of *Rhigozum trichotomum* and the average plant densities were 12 200 plants ha^{-1} on the red sands and 15 500 plants ha^{-1} on the white sands. If taken into account that densities off less than 3 000 plants ha^{-1} occurred here ten years ago, it shows that *Rhigozum trichotomum* is encroaching in these areas (in excess of 2.5 Mha) at a alarming rate and as such is causing problems for sustainable animal production. When managing natural resources the two key issues of concern are productivity and sustainability. If something has a detrimental effect on any one of these it must be addressed. Although functionally each savanna situation is unique and no two savanna systems can be managed in the same way, it is believed that the removal of the tree component (*Rhigozum trichotomum*), as is the case in the Molopo, will result in considerable increases in grass yields and livestock production in this vegetation type. Where eradication on such large areas of land is deemed necessary the use of chemicals offers the best prospect of killing these problem species in the shortest time. The effect of broadly applied Grassland 20P and Ustilan GG20 was therefore evaluated in terms of the percentage kill of *Rhigozum trichotomum* as well as its effect on grass production, grass density and species composition. The chemicals were applied broadly by hand at nine different rates including a zero rate as the control (0.0; 1.0; 1.25; 1.5; 1.75; 2.0; 2.25; 2.5; 2.75; and 3.0 kg ha^{-1}). Annual botanical surveys included bush density counts (TE ha^{-1}) to calculate bush mortalities for each application rate. Above ground grass production was determined by clipping six randomly chosen 1 m^2 quadrate per treatment (5 m x 80 m). Grass density and species composition (relative % density) were determined by counting grass tufts on a species basis in these quadrats. Results gathered over three years are presented and permit an assessment of: (1) the effectiveness of the different application rates of Grassland 20P and Ustilan GG20 in terms of bush mortalities; and (2) the increased grass yields and changes in species composition and grass density which can be expected after clearing bush on each soil type. Rainfall over this period was 345.5 mm (1987/1988), 258.0 mm (1988/1989) and 97.5 mm (1989/1990) (average 200 mm).

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Changes in the basal cover of grasses and the canopy cover of trees on the Soutpan Research Farm, South Africa

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Research started on Soutpan in 1958. During the early 1960s a system of non-selective grazing was applied. During this period the ecological carrying capacity was exceeded, the veld was degraded and beef production was poor. This led to the formulation of what ultimately became CSG. The mean rainfall is 500 mm. The early 1960s were very dry culminating in a disastrous drought in the 1965/1966 season. From 1967 to 1978 was a wet period, followed by the droughty 1989s and a disastrous drought in the 1991/1993 season. The stocking rate has remained below the ecological carrying capacity since 1967. During the 1980s a management change occurred and a lighter stocking was used. There was no significant change in the total canopy cover or the cover of the most important species, *Combretum apiculatum* and *Combretum zeyheri*. There was a small but significant increase in the canopy cover of *Dichrostachys cinerea*. *Acacia nilotica* increased significantly in the 1978 survey and then decreased by much the same amount during the 1993 survey leading to the question does this tree increase during wet periods. The total basal cover showed a highly significant increase from 1969 to 1978 and an even more significant decrease from 1978 to 1993. Considering the stocking rate this could only have been a climatic effect. Most of the grasses conformed to this pattern, decreasers, increasers, palatable and unpalatable. Some grasses diverged from this tendency. The basal cover of *Eragrostis rigidior* and *Eustachys paspaloides* decreased in every survey. *Eragrostis rigidior* is considered an increaser 2b and this would be expected. *Eustachys paspaloides* competes for space under trees with *Setaria sphacelata* (=*Setaria perennis*) which increased significantly in the 1978 results. *Eustachys* is usually considered a decreaser but this is probably an error as it should be an increaser 2. *Eragrostis superba* showed a significant decrease in the 1978 survey and was not recorded again. *Anthephora pubescens*, *Brachiaria nigropedata*, and *Aristida canescens* decreased significantly during the 1978 survey and then increased significantly in the 1993 survey. It is postulated that these being species typical of the drier regions they did not thrive during the wet years and did better in the dry years. *Aristida congesta*, considered to be an indicator of overgrazing decreased significantly in the 1993 survey. The relative percentage of decreasers did not change significantly over the years. The two unpalatable species, *Elionurus muticus* and *Loudetia simplex* are considered to be increaser 1 species and increased significantly in the 1978 survey and decreased significantly in the 1993 survey. The other perennials showed little change (increaser 2 species). Forbs and annuals increased in the 1993 survey. The expected improvements in species composition due to CSG did not occur, the veld had already recovered by 1968. The changes are probably all due to the climatic conditions before the surveys. A stocking rate not exceeding the ecological carrying capacity is unlikely to result in any important changes in species composition.

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The influence of stocking rate on animal performance and vegetation in Xeric Succulent Bushveld

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Three paddocks of Xeric Succulent Valley Bushveld (33°27'S; 25°22'E) were continuously browsed by Boer goat wethers at 72%, 126% and 297% of the recommended stocking rate (0.5 SSU ha^{-1}). Paddocks were uniform in terms of species composition, structure and density. Monthly weighing over the three years showed no differences in animal performance between the three stocking rates. Average live weight gains for the three years were, respectively, 37, 63 and 50 g d^{-1} per animal. Although an opening of the bush with increased stocking rate could be observed, no changes in species composition or plant density could be measured. Results confirm the presence of large amounts of accumulated browse in dense valley bushveld and the large potential for over-estimation of browsing capacity in this vegetation type.

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Land cover and natural resource status mapping of the Lake St Lucia hydrological catchment: an operational remote sensing technique

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The aim of the project was to produce, using satellite imagery, a comprehensive map on current land-use and resource status within the Mkuze, Hluhluwe, Nyalazi and Mzinene catchments that feed into the Lake St Lucia system. Both hardcopy and digital map formats have been produced, the latter suitable for incorporation into GIS (Arc-Info GRID). Lake St Lucia is one of the largest estuarine systems in southern Africa and is recognised as being one of the most important conservation areas in South Africa. Conservation authorities have identified the problem of decreasing run-off into St Lucia as a major threat to the system. The management of the catchment area of the rivers leading to the lake is therefore an important component of a conservation strategy for St Lucia. Information is required on the current state of the Mkuze, Hluhluwe, Nyalazi and Mzinene catchments in terms of riverine vegetation, wetlands, biomass, degradation, irrigation and development as an input to catchment planning. LANDSAT Thematic Mapper (TM) imagery (captured July-August 1991) was used, in conjunction with 1:50 000 scale black and white aerial photography to derive a land-cover/use map of all the specified hydrological catchments. A two-level approach was used to classify the imagery. An (unsupervised) spectral classification was used to define all categories that were spectrally separable, such as indigenous forest and bush; whilst a visual on-screen delineation of broader (spectrally confusing) land-cover/use units, based on contextual information, was used to build up the main background of the classification. The calculated true map classification accuracy is, with 95% confidence, in the range 79.3 to 91.9, based on a sample accuracy of 86.8 for 175 points. However, assuming that overall classification accuracy can only be as accurate as the minimum level achieved, and that a single value is the most unambiguous, it is easier to define the final map accuracy as being 79.3 percent. This still represents a high degree of accuracy in terms of the land cover mapping objectives of the study, and confirms that the final map is suitable for use in conservation land management. The classification is based on Level 6, precision corrected Gauss Conformal LANDSAT TM data (Lo 31°), with a registration accuracy of ±45 m (maximum). The map has an intended working scale range between 1:50 000 (maximum) and 1:250 000. The data are intended to provide a broad land use-cover classification of the catchments, and not to be accurate at single pixel level.

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The influence of planting date and water stress on water use efficiency and dry matter production of rye, triticale and oats

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Oats (*Avena sativa*), rye (*Secale cereale*) and triticale (*Triticale hexaploide*) were planted under a line source irrigation system on the experimental farm of the University of Pretoria. Three planting dates were used: the beginning of March, the middle of April and the end of May. The water application rate ranged from 7.5 mm h^{-1}, 3 m from the line, down to 3.5 mm h^{-1}, 10 m from the line. Rye cv. SSR1, triticale cv. Cloc 1 and oats cv. Overberg were established at a seeding rate of 50 kg ha^{-1}. The pH (KCl) of the soil was 5.3, the P and K status were 36 and 99 mg kg^{-1} respectively. Nitrogen was applied at 150 kg ha^{-1} in three dressings; four, ten and fourteen weeks after establishment. The experimental plots were 8 m x 2 m, divided into four split-plots (2 m x 2 m) arranged on the irrigation gradient. The subunits were equipped with hydroprobe tubes for measuring of waterlosses and irrigation demands. The subunits nearest to the line served as a control and were watered every week up to field capacity. The other subunits received 83%, 67%, and 50% of the water applied on the control plots. Rye and oats gave the best water use efficiency. Water use efficiency improved with a decrease in water application, the best water being obtained by rye planted during the middle of April, followed by oats planted during the beginning of March. These differences were not statistically significant. The end of May planting gave a significantly lower water use efficiency than the other two planting dates. The best yield was obtained with oats planted in March. Oats were the least sensitive of water stress. There were

no significant differences in yield between the different crops in the April establishment. Triticale,planted in May, gave the best yield, obtained with the 83% water application, but it was not significantly better than the 67% application. There was a significant species/planting-date interaction, in both yield and water use efficiency. Rye showed a greater increase in water use efficiency between the March and April planting dates than triticale. Oats showed a decrease in water use efficiency between the March and April as well as between April and May planting dates. Oats and triticale showed a decrease in yield between the March and April planting dates while rye showed an increase. Oats and rye showed a greater decrease in yield between the April and May planting dates than triticale. It is therefore, concluded that the water use efficiency improves with a decrease in water application, and the best efficiency and highest yield were obtained with the first planting date. Oats had the highest yields and its water use efficiency was equal to that of rye.

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A decision-support system for pasture species and cultivar recommendations in the winter rainfall area of South Africa

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The poor application ratio of new technology by farmers has been identified as a major factor limiting pasture production and utilisation in the winter rainfall area. This was *inter alia* attributed to the poor flow of information from research to advisors and farmers. In an effort to assist this process, a range of decision-support systems are being developed for the winter rainfall region. As a first step a heuristic decision-support system was developed for the selection of pasture species and cultivars in various areas of the winter rainfall region of South Africa. This system is mainly aimed at advisors, although leading farmers should also be able to use it. Irrigated, as well as rainfed pastures are accommodated. Recommendations are based on soil potential and aridity. Soil potential is derived from resource units which are based on soil type and aspect. Four categories of soil potential are provided for, viz. nil, low, medium and high potential. Aridity is a simple dimensionless index with values between 0 and 1 and derived from the ratio monthly rainfall (mm per month) to monthly pan evaporation (mm per month). The system provides for pastures based on the most important pasture legumes used in this area, (i.e. lucerne, medics, subterranean clover, balansa clover, white clover, red clover and Persian clover). Grasses such as tall fescue, cocksfoot, perennial ryegrass, Westerwolds ryegrass, Italian ryegrass, phalaris and kikuyu are also provided for as components of mixtures based on the aforementioned legumes. Detailed lists of cultivars and certain attributes of the various cultivars, such as insect, disease and grazing resistance, are also provided.

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Vegetation cover as a controlling factor for runoff and soil erosion in thorn-tree rangeland

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Intensive grazing, termite activity and droughts reduce vegetation cover. Compaction of the topsoil and crust formation reduce infiltration. These factors lead to higher rates of runoff, soil erosion and reduction and instability of forage production. Quantitative data of degradation processes are required to manage grazing and vegetation cover for sustainable production. Runoff trials on debushed redsoil rangeland in a semi-arid environment started at Matopos Research Station, Zimbabwe, in 1980. Current objectives are to measure runoff and soil losses from a well-grassed control treatment and compare these with the effects of reduced cover. This is achieved by clipping grasses at different heights once a month. Vegetation cover and grass productivity are monitored. Rainfall, runoff and sediment loads are measured and sampled after each runoff event. A few high energy rainfall events account for most runoff and soil losses that occur. Soil losses from plots with low vegetation cover are about three times higher than from the control plots. Rate of erosion probably exceeds the rate of soil formation. A model relating mean annual soil loss to aerial vegetation cover

will be presented and compared to the crop cover submodel of SLEMSA. The model indicates that vegetation cover can be managed within a definable range for sustainable livestock production.

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A story of successful conversion from maize to lucerne

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Over the past ten years conversion of cultivated croplands to pasture for livestock farming was seriously addressed in the Highveld Region. When, however, the execution thereof was unplanned, financial success was not always achieved due to initial cash flow problems, livestock farming not redeeming the maize debts and ignorance pertaining to livestock purchases and management practices. An example of successful conversion was carried out by Mr Koos du Plessis on his farm "Witwal", situated in Vredefort district, in the northern Orange Free State. The incentives for conversion were: (1) low potential Westleigh soils with an 18% clay content in the top layer and an effective 400 mm soil depth, previously under maize, realized low income and/or high losses in terms of R ha^{-1}; and (2) expansion of the existing small merino herd to benefit from wool prices which were excellent at that stage (1983 to 1985). Due to the adaptability and drought resistant characteristics, lucerne (cultivars: SA Standard, Baronet and CUF 101) was gradually established, on the available lands, to suit the needs of his merino farming practices as well. Sufficient crop residues were available for winter grazing. This gradual conversion enabled him to master the intensive management practices of lucerne production for sheep as well as increasing the herd. The sheep now restricted to a relatively small area simplified supervision. The veld previously occupied by sheep became available for expansion of the beef cattle herd. Mr du Plessis, together with local extension officers, was able to determine reliable norms, from data collected over the past ten years, of which the most important are: (1) a long-term production of 5 t ha^{-1} a^{-1}; (2) a grazing capacity of 12.3 SSU ha^{-1} over the nine-month growing season; (3) a 35% wool production increase - from 5.3 kg to 8.2 kg per sheep per annum; (4) a lambing percentage of 124% (previously 90%); and (5) four-month old weaning mass of 24 kg per lamb. The reasons for success with conversion are gradual incorporation of the livestock factor ("fill the farm through breeding and not through buying"), gradually gaining of experience to manage this system efficiently, and good supervision and thorough documentation of records.

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Creation of facilities to study the influence of soil water availability on forage crops

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Facilities were developed to create a soil water gradient inside a fibreglass tunnel on the experimental farm of the University of Pretoria. Two replicates of 18 plots each were laid out measuring 5 m x 1 m, and separated by plastic sheeting to a depth of 0.6 m to separate different species/cultivars in the grass root zone. A dripper line laid on the middle of each plot was used to create a water gradient from 10 L h^{-1} at point A, to 2 L h^{-1} at point E, within each plot. Grass seeds were sown in plastic containers containing a growth medium consisting of sand, peat and vermiculite. The seedlings were thinned out to three seedlings per container. When the seedlings reached a height of 150 mm they were clipped to 70 mm to stimulate tiller development. After two months the seedlings were transplanted to the fibreglass tunnel. Four plants formed a biological shield between each set of three monitor plants situated around each watering point. All the plants were evenly irrigated until strong plants developed, and then cut to 70 mm before the different water availability treatments were applied. The influence of this water gradient on eighteen perennial sub-tropical

grasses (including *Cenchrus ciliaris* ecotypes, *Anthephora pubescens*, *Bothriochloa ischeamum*, *Eragrostis curvula*, *E. lehmaniana*, *Panicum maximum*, *P. coloratum*, *Digitaria eriantha* & *D. californica*) was studied in terms of biomass production, plant height, tuft diameter, number of inflorescence and fractional interception.

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Veld monitoring in the sour bushveld of the Waterberg, South Africa

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The sour bushveld of the Waterberg covers more or less 900 000 ha. No agricultural research station represents this area. Limited quantified data and norms for natural veld are therefore available. The lack of data and norms handicaps effective extension work and advisory actions. *Terminalia sericea/Eragrostis pallens* veld covers a great part of this area. A camp that is well representative of this veld type and which belongs to a conservation farmer was identified. The utilization of veld as well as the change in composition and production over time are monitored under practical farming conditions. The object is for this camp to serve as a bench mark or reference camp in extension. Five 100 m by 2 m transects were laid out. The following parameters were recorded: (1) grass species composition (using a 500-point survey); (2) grass production per annum, under as well as beneath trees, with the aid of exclosures; (3) percentage utilization of three palatability groups, under as well as beneath trees (120 0.5 m x 0.5 m quadrats were used directly before and directly after the camp was grazed by cattle); (4) canopy cover, density and composition of the woody layer; and (5) records of LSU grazing days, rainfall and lick intakes. The data for the 1991/1992 and 1992/1993 seasons are briefly as follows: (1) grass composition - palatable group 42%, less-palatable group 10% and unpalatable group 48%; (2) grass production - 1991/1992 524 kg DM ha^{-1}, 1992/1993 550 kg DM ha^{-1} (average rainfall is 630 mm, and the rainfall for these two years was respectively 221 mm and 270 mm); (3) no pattern in utilization of the three palatability groups could be found under practical farming conditions (the stocking rate was 11 ha per LSU and 8 ha per LSU respectively for the two seasons); and (4) canopy cover of the woody layer is 30%. Conclusions drawn from the study indicate that to determine the percentage utilization under controlled practical farming conditions where the stocking rate varies from year to year, is unpractical. Data cannot be used. One camp is inadequate to obtain useful data. Different treatments in different camps must rather be evaluated and compared. Two additional camps adjacent to the above mentioned will also be monitored in future. The condition of the three camps is more or less the same at present. Three treatments will be applied, namely a 35%, 55% and 75% utilization. These percentages represent a light, moderate and heavy stocking rate on veld. The objectives are to serve as demonstration plots during persuasion actions, and to obtain quantified data and norms for extension purposes. Preference sequence in the growing as well as dormant seasons will be monitored.

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The influence of degree of defoliation on the yield and recovery of oldman saltbush

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Although it is recommended that oldman saltbush is heavily defoliated followed by a long recovery period, indications are that this might inhibit regrowth and even kill individual plants. Some control over the degree of utilization is therefore necessary. To investigate the resilience of this crop, a study was undertaken at the Hatfield research farm of the University of Pretoria. Seedlings were established in a deep fertile clay loam during autumn. As a result of good rains shortly after establishment, plants thrived and pruning treatments could be applied during the following spring and summer (September & December). Plants were defoliated to a height of 50, 100, 200 and 300 mm above the soil surface, or not at all. During the spring of the following year (September 1991) the DM yields for the different plant fractions were determined. Plants defoliated to a height of 50 mm, had a significantly lower growth rate than plants which were defoliated to a

height of 300 mm. The highest mean growth rate was obtained where plants were defoliated moderately (200 mm), while severely defoliated plants (50 mm) realised the lowest growth rate. Plants not defoliated in both seasons, realised a lower growth rate than plants that were defoliated moderately, which emphasizes the stimulating effect of a moderate defoliation. Plants defoliated during summer had a lower growth rate than plants defoliated during spring, probably as a result of the shorter recovery period. Plants that were not defoliated had a higher proportion of inedible wood. It is of paramount importance that oldman saltbush should be moderately defoliated to stimulate the production of edible material. The degree of defoliation had a significant influence on growth rate and thus on the recovery of oldman saltbush. Growth rate differences of up to 60 g DM per plant per month, as were obtained with different treatments, could have a relatively big influence on the grazing capacity of a paddock of a few hectares. An oldman saltbush stand which is moderately defoliated should have a higher vigour, which ensures sustained production and more regular utilization. With moderate defoliation, more material will probably be available as fodder in the long term.

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The influence of season and degree of utilization by sheep, on the vigour and recovery of oldman saltbush

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Most woody plants are stimulated by defoliation, as only a part of the available biomass is usually removed. The intensity and season of utilization, and the recovery period determines recovery of woody plants. The optimum degree of utilization of oldman saltbush is unknown. It is recommended that plants be heavily defoliated, and then allowed to recover for the remainder of that year. There are indications however, that some plants die as a result of such treatment, regardless of the length of the recovery period. To investigate the resilience of this crop, a study was undertaken at the Hatfield research farm of the University of Pretoria. Camps of 0.1053 ha with plants of about one meter high (one year after establishment), were used. Camps were grazed by six young mutton merino rams, until the desired degree of utilization was obtained. Two utilization intensities, a 100% and a 50% utilization were applied, during autumn, winter and spring. To determine utilization and recovery, individual plants were photographed before and after treatment. DM yields were determined three months after the last treatment. The ability of saltbush plants to recover, even after total defoliation was relatively good. Plants that were totally utilized had however, a higher mortality. On average 477% more plants died when totally defoliated, than when moderately moderately defoliated. Quicker recovery rates were obtained with moderate utilization, for all treatments. Plants utilized during spring recovered quicker, despite the shorter recovery period. This was probably due to the favourable growing conditions. With moderate utilization the animal could enhance the quality of his diet by grazing selectively, as it was found that the quality of the grazing deteriorates as the grazing period progresses. Better animal performance could therefore be expected. Moderately utilized plants would be better able to cope with stress such as drought, as recovery is faster. With a percentage of the moderately defoliated plants, some of the material that was left would by the next season, be out of reach of small stock. Such plants will also develop a higher proportion of useless wood. As the recovery of most of the plants totally defoliated was promising, a utilization somewhere between the moderate and total defoliation that was used in this study, might be the optimum level of utilization. The influence of, for instance, a 75% utilization on plant survival should therefore, be the determined.

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The influence of a pruning treatment before transplanting, on oldman saltbush (*Atriplex nummularia*) seedling development

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It is recommended that oldman saltbush (OMS) seedlings be pruned to a height of approximately 200 mm before transplanting, so as to limit transpiration losses and facilitate transplanting. The influence of pruning on the vigour and mortality of OMS seedlings is not known, although pruning will definitely temporarily inhibit root growth. The influence of a short recovery period after pruning and before transplanting is also unknown. The study was undertaken at the Hatfield research farm of the University of Pretoria. Seed was soaked for three days and sown in washed sand. Seedlings were planted in a clay soil, in one kilogram plastic bags. Moisture and nutrients were not limiting factors. Pruning treatments were applied over a six-week period after transplanting. After this period half of the replications were evaluated, by determining the DM yield of the different plant fractions. The rest of the plants were transplanted in a deep Hutton, and harvested five months later, at a height of 50 mm above the soil surface. The DM yield of the different plant fractions was determined. As treatments were applied over a three-week period, plants in different treatments had different recovery periods. As expected, plants evaluated after the pruning treatment, differed significantly from each other in terms of DM yield. Root growth especially, was severely inhibited by pruning, even shortly after treatment. Differences in DM yield five months after transplanting were not, however, significant, but severely pruned plants had much lower yields. Under more stressful climatic conditions, the differences might have been greater. Relatively poor regrowth of plants that were severely pruned just before transplanting, in relation to plants even more severely pruned ten days before, highlights the positive influence of a short recovery period. According to these results it would appear that a moderate pruning should not have a negative influence on seedling development. Conversely severe pruning, especially under dry climatic conditions, could inhibit growth. As a result of a higher vigour, moderately pruned plants should be ready for utilization earlier.

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Seasonal patterns in nutrient status of *Themeda triandra* in Natal

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Southern African rangelands are traditionally separated into extremes of 'sweetveld' and 'sourveld' on the basis that mature plants have different capacities to supply nutrients to livestock during winter. This is not a function of species composition, as many species are common to both types. Graziers attempt to overcome this decline in forage quality by providing dietary supplements. A better understanding of nutrient supply from range is needed so this study was carried out to characterise the seasonal patterns in quality using *Themeda triandra* Forssk., an abundant species common across rangeland types. At six locations ranging from 'sweet' to 'sour' veld green leaf blade from *T. triandra* was collected at *c.* three month intervals for 23 months. Sites were located at Mkuze (27°38'E; 32°10'S, 6), Umfolozi (28°18'E; 31°50'S, 5), Magudu (27°30'E; 31°40'S, 4), Cathedral Peak (28°58'E; 29°15'S, 6), Highmoor (29°15'E; 29°38'S, 4) and Pietermaritzburg (29°40'E; 30°24'S, 4). Material was dried (60°C; 48 h), milled and then subjected to cellulase digestion (CDMD) and elemental analysis (N, P, K, Ca & Mg) and presented as seasonal trends. Despite inconsistent results across years, considerable inter-site differences in forage quality were found. The greatest differences were in CDMD, N, P and K contents with smaller differences in levels of Mg and Ca. In all cases the 'sour' sites (Cathedral Peak and Highmoor) had lower nutrient levels than the 'sweet' (Mkuze, Umfolozi & Magudu) with the 'mixed' group intermediate between these two or are inconsistent. Ratio analysis of Ca/P and K/(Ca + Mg) showed wide variation both within and between years. A striking feature of these data is the relatively low variation, amongst sites for the 'sour' group compared to the 'sweet' and 'mixed' groups. These data suggest that rangelands in Natal supply an adequate level of only Mg. Sour sites have adequate levels of N and K from September to March but not during autumn and winter (April to August). Ratio analysis of these data identified periods where the nutrient content of the forage on offer is imbalanced, reducing the usefulness

of nutrients supplied. Despite the inadequate levels of Ca and P, the ratio of these is above the level of 1 to 2 suggested by most authors. There are, however, periods where there is a major excess of Ca and the ratio exceeds 6. The K/(Ca + Mg) ratio should be less than 2.2 for most locations. The data presented here suggest that it is important to consider the routine use of appropriate summer supplementation with regard to improving animal production from rangeland. A major limitation of this study is that only a single grass species was used. This was necessary to prevent inter-species differences confounding results. The possibility does exist that other species may supply levels of minerals not available in *T. triandra*. The formulation of improved dietary mineral supplements, aimed at both the level and balance of minerals, could be achieved. This will need to be done in conjunction with studies of the energy supply from these rangelands.

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1993 ANNUAL GENERAL MEETING

UNCONFIRMED MINUTES OF THE 28TH ANNUAL GENERAL MEETING OF THE GRASSLAND SOCIETY OF SOUTHERN AFRICA HELD AT THE UNIVERSITY OF THE ORANGE FREE STATE ON WEDNESDAY 20 JANUARY 1993 AT 17H00

PRESENT

Council Members: Dr M.M. Wolfson (Chairman), P.J.K. Zacharias (Vice-President), M.B. Hardy (Acting Secretary), D.C.W. Goodenough (Treasurer), Dr R.P. Ellis (Scientific Editor), C.R. Hurt (Publications Editor/Bulletin Editor), F.O. Hobson (Public Relations), Dr A.J. Aucamp, Dr L. du Pisani.

Member Institutions: Kynoch Kunsmis

Members: F. Archer, K. Adams, A. Aucamp, S.A. Barnard, F.V. Bester, E.N. Boeke, J. van Bosch, L.T. Botha, W.A.S. Breytenbach, J.A.E. Campbell, T.G. Coetzee, G. Coetzer, C.S. Dannhauser, M.S. de Beer, H.O. de Waal, C.H. Donaldson, L.G. du Pisani, P.C.V. du Toit, P.F. du Toit, R. Eckard, R.P. Ellis, C. Fabricius, N.J. Fair, Y. Ford, H. Fouche, D. Goodenough, C. Helm, F.O. Hobson, C.R. Hurt, L. Jarvel, G. Jordaan, J. Kappeyne, S.H. Kemp, K.D. Kirkman, I. Knight, D.C. Kotze, D.J. Krynauw, J. Lindeque, J.C. Martens, F.R. Mckenzie, H.H. Meissner, N. Miles, A. Moore, T.A. Morley, J. Mynhardt, T. O'Connor, P. O'Reagain, D.J. Olivier, U. Orfer, A.R. Palmer, G.M. Peddie, J. Peel, P.A. Pieterse, A.L.F. Potgieter, J. Potgieter, J.J. Rall, E.R. Reed, C. Richter, P. Roos, J.C. Scheepers, L. Scheepers, T.E. Skinner, H.A. Snyman, R.E. Steynberg, T-L. Swain, D. Swart, N.M. Tainton, J.F. Theron, S.T. Tshenkeng, B. van Ginkel, F. van der Heyden, H.C. vd Westhuizen, W.vR. Versfeld, A.D. van Greunen, A.J. van Wyk, F.J. van Eeden, J. van Eck, K. van Oudtshoorn, W. van Rensburg, E.A. van Zyl, A.vZ. Bronn, P.S. Venter, H.M. Venter, I. Venter, A. Verschoor, L.F. Vorster, W.S.W. Trollope, M.J. Willis.

Apologies: L.F. Arnott, P.E. Bartholowmew, J. Briers, J. Danckwerts, R. Davies, E.B. Dickinson, L. du Toit, C. Everson, T. Everson, D. Grossman, D. Harris, G. Hatch, G. Hefer, G. Hyam, F.P. Jordaan, G. La Cock, P. le Roux, C.I. MacDonald, M.T. Mentis, A. Morrison, J. Naicken, L. Pansegrouw, J.C. Pauw, L. Pauw, M.J.S. Peel, H. Potgieter, J.D.H. Reusch, A. Smith, G.C. Stuart-Hill.

1 WELCOME

The Chairman opened the meeting and thanked all for their attendance.

2 ADOPTION OF THE AGENDA

A few additions proposed to the draft agenda all of which it were accepted. Proposed: Mr Hardy. Seconded: Mr Kappayne.

3 APPROVAL OF MINUTES

After corrections of three points (viz. members 4.1 and 4.2.2) the minutes of the 27th AGM held on 21 January 1992 were accepted as a true reflection of the Stellenbosch meeting. Proposed: Dr A J Aucamp. Seconded: Professor W S W Trollope.

4 MATTERS ARISING

4.1 Joint I.R.C. with Kenya

Professor Tainton reported that, despite numerous efforts, he has had little success in contacting Kenya's representatives. Apparently the East African Grassland society has 'folded'. Professor Tainton went on to report that, as we had not been successful in our application for the 1997 IGC (the 1997 IGC has been allocated to Canada), Council had decided to bid for the for 1999 IRC Congress.

4.2 Prestige Grazing Days

Mr Hobson reported that a protocol has been drafted for the PGD's. A copy of the draft is available to members on request. Final details depend largely on the results of our Strategic Plan. In summary:

a) PGD's must be held in response to a need, we must not force the days.
b) PGD's must not be seen as competition to existing organizations eg Dept. of Agriculture.
c) The proceedings of a PGD must be published. Publication costs to be included in the fees for the day. A disclaimer must also be included stating that the ideas and arguments presented/discussed at the PGD are not necessarily the policies/views of the GSSA.
d) The PGD's must also be used as 'think-tanks' and not simply as 'information' days. As such they may only appeal to 'top' farmers and advisors.
e) The GSSA must be seen to be responsible for the PGD's. However, any other organization involved in the day must be acknowledged in proportion to their contribution.

Mr Hobson also reported that six PGD's were held during 1992 including three PGD's in Zimbabwe.

4.3 Professional Affairs Committee

Professor Tainton reported, on behalf of Dr Grossman, that the PAC is now in operation. The steering committee, who were responsible for the development of the 'code-of-ethics' document and operation of the PAC, were unanimously elected as members of the PAC with Dr Grossman as Chairman. Seven applications to be registered as Professional Grassland Scientists have been received so far. Application forms are available from the Administration office.
Mr Kappayne asked about SACNAS. The Chairman reported that there had been no further developments.

4.4 Developing Areas Group

A Symposium on the role of the Grassland Scientist in developing areas was held at the Cathedral Peak Hotel from 16 - 18 September 1992. A report on the proceedings of the Symposium will be presented in the Bulletin and the Proceedings of the 1st Symposium of the Developing Areas Branch of the GSSA will be published if funds permit.

4.5 International Grassland Congress

See reference to this in 4.1.

4.6 Amalgamation of Journals

Dr Ellis reported that there had been no further developments in this regard. We have, however, exchanged lists of referees with the Australian Rangeland Society and we use quite a number of their referees for our Journal.

4.7 Time of Congress

Mr Zacharias reported that 666 forms had been sent out to members (at considerable cost to the Society) and that only 78 (12%) of these had been returned. Of the 78 returns 31 were in favour of a January Congress, 32 for June/July and 15 were 'happy' with status quo. Council had therefore decided not to recommend a change to the time of Congress. It was also suggested that January was a good time of the year to view veld and pasture research and practice. The Chairman was asked for discussion from the floor. Miss Swain indicated that there may have been a problem in the postal system in that many members had not received their forms. A show of hands indicated that a large majority of those present had in fact received the questionnaire. After

further discussion it was resolved that Congress should continue to be held in January.

5 EDITORS REPORTS

5.1 Scientific Editor

Dr Ellis reported that 52 papers had been submitted for publication during 1992. Of these 18 were rejected, 13 accepted and 21 were in the editorial process. He expressed his concern that we were on the 'breadline' as far as submissions were concerned and this could have implications regarding the viability of the Journal. Only 182 pages were published in the 1992 volume of the Journal which was 32 pages less than the previous (1991) volume. Dr Ellis stated that he was ready to stand down as Scientific Editor but had been persuaded to remain in the position for another year. Fortunately for the Society there were several members who had indicated their willingness to take on the portfolio next year. The new editorial committee (1993) comprised of Dr R Ellis, Mr R Eckard, Mr M Hardy, Mr P O'Reagain, Mr T O'Connor, Mr N Smit, Mr F van der Heyden and Mr C Fabricius. One or two other members of the Society will be approached to become members - particularly those with expertise in cultivated pastures. The editor thanked Dr's du Pisani and Smith for their contribution to the publication of the Journal. Dr Ellis further reported that our application for accreditation to ISI (Science Citation Index) had been turned down. We will re-submit our application next year. There is likely to be a problem, however, since we are definitely changing publishers and we may be changing our name (the name change being dependent on the Strategic Planning exercise). ISI requires a 4 year evaluation period under a single publisher as one of their criteria for acceptance of a Journal for citation. Problems and implications of a change in publisher will be discussed by publication editor (Mr Hurt). The editor pleaded with those who submitted papers for publication to read the instructions to Authors published on the back cover of the latest number of the Journal. He thanked all the referees for their valuable contributions to ensuring a high standard of publication in the Journal. Seventy seven referees were used during 1992. Their names will appear on the inside page of the 1993 volume. Special thanks to the efforts of the editorial committee and the Publications Editor for all their hard work.

The Chairman thanked Dr Ellis for his report and asked for discussion from the floor.

Mr O'Reagain pleaded with referees to take their jobs/responsibilities seriously or not to accept papers for refereeing.

Dr du Pisani suggested that the low number of papers submitted for publication may have been due to the policy of publishing only in English, a decision which could have influenced the number of submissions by Afrikaans speaking authors. He asked for a formal list of individuals (volunteers) who were willing to help with English of Afrikaans speaking authors. The following members indicated their willingness to assist with this: Dr M Wolfson, Mr P Zacharias, Mr M Hardy, Mr R Hurt, Dr C Scheepers, Mr A Palmer, Mr F Hobson, Mr F du Toit, Professor W Trollope, Mr T O'Connor, Mr E Brink.

Dr Scheepers proposed a vote of thanks to Dr Ellis. The meeting was unanimous in their agreement.

Dr Scheepers also proposed that report of the Scientific editor be accepted. This was seconded by Mr Adams.

5.2 Production - Publications Editor

The Publications Editor requested authors to publish locally rather than in overseas journals. Page charges by the BSP have increased from R65 to R110. In an attempt to recoup these charges Council has agreed to the recommendation of the Editorial Committee that papers will not be published in our Journal unless page charges are submitted together with the galleys (i.e. when galleys are returned to author for final editing they will be accompanied by an invoice). The Publications Editor thanked those authors whose submissions were according to the 'Guide to Authors' and appealed to the others to ensure that their papers are prepared according to 'Guide to Authors'. He also raised the issue of changing our publishers. This is an inevitable consequence of BSP being re-incorporated into FEST (The foundation for Education Science and Technology). We must also consider changing the name of the Journal at the same time as these two issues have an influence on the International standing and editing of our Journal. Changing Publishers will have severe consequences on the financial viability of the Journal. These are two scenarios

1 We stay with FEST - a cultural organization within the present government which has little experience in publishing scientific journals and even less contact with overseas distribution of the Journal - members of BSP who worked with our Journal in the past have either resigned or have been relieved

of their responsibilities for producing our Journal. A second point is that in a changing South Africa it is most likely that Government funding for organizations such as FEST will change for the worse, which will have negative 'spin offs' for the publication of our Journal.

2 The second scenario is to change publishers now or become our own publisher and contract the job to a professional body. Politically this also has financial complications.

The Chairman asked the floor if there was any discussion.
Mr Kappayne, quite forcefully, suggested that it was the duty of the duly elected members of council to take such decisions on behalf of the members. He believed that only Council members were sufficiently informed to make these sorts of decisions. The meeting could only act on the advice of Council. This was agreed to by the AGM.
Mr Pieterse proposed that we accept Mr Hurt's report and Miss Swain seconded the proposal.
Mr Hurt then thanked the staff of BSP who had again ensured a high quality publication and also thanked the Editorial Committee and Mr P Zacharias for all their help and inputs.
The Chairman then thanked the Publications Editor for all his efforts.

5.3 Bulletin Editor

Mr Hurt reported that the Bulletin appeared to be going from strength to strength. Members were submitting articles and generating debate. He stated that he would be standing down a Editor and that Mr Morris will take over. Mr T Morley will assist Mr Morris from Volume 4.1.

6 TREASURERS REPORT (as audited by the Society Auditors)

Mr Goodenough had circulated copies of the Treasurers report before the meeting so members were aware of its content. He highlighted a number of issues:

1 Overall assets are up by R15 774 on last year;
2 Income is up by approximately R13 000 whilst expenditure is up by approximately R9 000;
3 Why the subscription increase? The proposed budget reflects a R6 090 loss for 1993 if subs are not increased. Further costs are likely in view of our strategic planning exercise and we cannot afford to 'eat' into capital;
4 Council is concerned about: 1) Page charges: We recovered only R1 050 as opposed to an expected R13 000. 2) Annual subs: 100 members have not paid their 1992 subscriptions i.e. a loss of approximately R8 000. There is also an extra load on our Administrator who repeatedly contacts the 'offenders'. 3) Member institutes down to *c.* 20. What is the problem? 4) Administration costs will continue to increase as we move away from employer organizations subsidizing the transport, accommodation and salary costs of the Society's management. For example EXCO meetings may cost in the region of R6 000 per meeting.

Mr Goodenough then called for comment. Mr Kappayne objected to the suggestion, para. 8 on page 1 of the financial report, that surplus funds be allocated to assist members to attend the 1994 Congress in Zimbabwe. He considered this 'unfair' as those members who travelled from countries to the north of South Africa were never subsidized by the Society. The Chairman stated that Mr Kappayne had a point and asked for further comment. After some discussion Mr Kappayne proposed that Council make the final decision. Professor Tainton seconded the proposal.
There being no further discussion on the financial report Professor Tainton proposed that the financial statement be accepted. This was seconded by Dr Aucamp.

7 TRUST REPORT

Professor Tainton reported on behalf of Dr Hildyard. Professor Tainton asked for discussion from the membership. After some discussion it appeared that there was no real enthusiasm for the R100 ticket 'car' club idea. There may be some benefit to selling tickets at R10. Members were asked to comment on, and make additional, suggestions regarding fund raising via post to the Administrator. Professor Trollope proposed acceptance of the report. Dr Miles seconded the proposal.

8 FOGS

The Chairman, Mr D Ivy, was not present and no report was forwarded. Mr Kappayne suggested that all reports should be published in the Bulletin. The Chairman agreed.

9 STRATEGIC PLAN FOR THE SOCIETY

The Chairman indicated that the discussion should be directed at getting the response of members to ideas emanating from the Strategic Planning Session held by Council last year and summarized in the latest Bulletin which each delegate should have received as they registered. She requested that, since there was obviously no chance of making final decisions during the AGM, members submit their responses and ideas on the various scenarios, in writing, to the Council. The following should be considered:

1) name for the Society.
2) what are the most important focus areas of the Society?; and
3) briefly - what strategic action should we follow?

Discussion was then opened to members. There was much debate indicating the broad spectrum of ideas ranging from - why change any thing i.e. maintain status quo, particularly since we are (in the status quo scenario) a dynamic Society who, in any event, change and adapt when required. We are also growing society so what is the problem? It must be recognised that we have to have some focus and, in particular, if we are to be a professional society within the Mission Statement as published, we must develop to be the authority in our discipline and be recognized as a necessary profession with the strength as a successful profession with the strength to 'lobby' our cause.
After further discussion it was proposed that we adopt the expanded or more flexible scenario (Scenario 3). This proposal was accepted by all.
The Chairman thanked all those who participated and requested delegates to please put their ideas to paper to give Council guidelines in their deliberations.

10 CONGRESSES 29 & 30

10.1 Congress 30 Venue

The Chairman reported that a single written invitation had been received from the Highveld Agricultural Development Institute for the 1995 Congress. Two venues were proposed: the Agricultural Centre at Potchefstroom approximate costs of R300/person, and Hunters Rest/Kroonpark Holiday Resort approximate costs of R750/person. The meeting was unanimous in its decision to accept the invitation and that the Congress be held at the Agricultural Centre, Potchefstroom.

10.2 Congress 29

Mr Zacharias reported that arrangements for the Zimbabwe Congress were proceeding well in collaboration with the Zimbabwe Grassland Society. Briefly it will be a five day congress. The first two days will be devoted to intensive pasture systems, the third day to an excursion and the last two days to extensive systems. It may however not be possible to arrange the congress in this way if a balanced number of papers from the two groups were not received.

11 GENERAL

11.1 Congress Excursions

Mr Donaldson requested that the organizing committee of each congress should attempt to organize an excursion. He felt that it was an important and integral part of the congress proceedings. Mr Zacharias stated that excursions are being planned for the Zimbabwe Congress. The meeting agreed that each organizing committee should consider the merits of including an excursion in the programme.

11.2 Congress Awards

The Chairman requested that the announcement and presentation of awards be held over to the Congress dinner. This was unanimously accepted.

1.3 Poster Presentations

Mr Pieterse requested that the time allocated to each poster should be drastically reduced (15 min at the present Congress) and that authors should be requested to stand at their poster. After some discussion it was generally agreed that poster presentation and question time should be reduced to 10 minutes and argued that those who wished to speak to the authors should do so at tea and lunch times or during free time. Presenters could not be expected to stand at their posters on the off chance that someone may be interested.

11.4 Procedure for nomination of office bearers

Mr P O'Reagain suggested that we alter the procedure for the nomination of office bearers. He suggested that prior to election each one should be identified and a brief CV should be presented. Council will look into the procedure for implementation at next congress. Dr Palmer suggested a 'block' nomination to change council from region to region. The Chairman stated that this idea had previously been tried and lead to major discontinuities. She also stated that we should wait for the completion of the Strategic Planning exercise before we change the present system.

12 ELECTION OF OFFICE BEARERS

The Chairman announced that two additional Council members, the PRO position and the position of vice-president had to be decided. Mr Zacharias reported that only two duly signed, written nominations had been received for the Additional Council member positions in favour of Mr Felix Hobson and Mr Chris Fabricius. Both were appointed unopposed. Mr Zacharias reported that only one nomination for the PRO position had been received in favour of Mr K Kirkman. Mr Kirkman was appointed unopposed.
There were two nominations for the post of vice-president in favour of Professor Snyman and Dr Louis du Pisani. After a secret ballot Prof. Snyman was duly elected to the position of vice-president.
The Chairman then called for permission to destroy the ballot. The meeting agreed and the ballot was duly destroyed.

13 CLOSURE

Dr Wolfson concluded the meeting by thanking the Society for their support during her term of office. She welcomed the new Council members and wished them well with their contribution to the Society during their term of office.
Dr Wolfson then handed the Chair to Mr Zacharias and wished him well in his term as President.
Mr Zacharias, in turn, paid tribute to Dr Wolfson and reminded the Society of her leadership and hard work during difficult, changing times. He thanked her for her untiring efforts on behalf of the Society and wished her well during her term as immediate past-President, noting that the Council will find something for her to do, if she doesn't beat them to it.

The meeting closed at 16:30.

CHAIRMAN: .....

SECRETARY: .....

DATE: .....

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DIARY

CONGRESSES, SYMPOSIA & COURSES

6-11 January 1994
Dunes '94. International Coastal Dunes Conference, University of Port Elizabeth. Contact: Prof GC Bate, Botany Dept, UPE, PO Box 1600, Port Elizabeth, 6000. Tel: (041) 504 2396 or Fax: (041) 53 2317

14-17 January 1994
Erosion and desertification in regions of mediterranean climate (MED). University of Cape Town. Contact: Dr Mike Meadows, Dept of Environmental and Geo-graphical Science, UCT, Private Bag Rondebosch 7700

17-21 January 1994
Grassland Society of Southern Africa, 29th Annual Congress (!). Faculty of Agriculture, University of Zimbabwe, Harare, Zimbabwe. Contact: Richard Winkfield, Chairman GSZ, P O Box MP 84, Mount Pleasant, Harare, Zimbabwe or John Clatworthy, Organising Committee, P O Box 113, Marondera, Zimbabwe.

1-4 February 1994
Efficient utilization and management of water resources in Africa. Khartoum, Sudan. Contact: Dr Gamal Abdo, Faculty of Engineering and Architecture, University of Khartoum, PO Box 321, Khartoum, Sudan.

28 - 31 March 1994
Thirty Third Annual Congress of the South African Society of Animal Science. " Findings and Future Directions". Warmbad Aventura Resort. Four speakers from abroad supported by a host of local animal scientists. Contact: The Organisers, SASAS Congress 1994, P O Box 166, IRENE, 1675.

23-25 March 1994
People, Rangelands and Development.
Maseru, Lesotho. Second Symposium of the Developing Areas Branch, Grassland Society of Southern Africa. Contact: Grant Hatch, University of Natal, Deptartment of Grassland Science, P O Box 375, Pietemaritzburg, 3200.
Telephone number: (0331) 955 509 or Fax (0331) 955 067.

12 - 16 June 1994
Eighth Asian Symposium on medicinal plants, spices and other products (ASOMPS VIII). Melaka, Malaysia. Sekretariat ASOMPS VIII, c/o Department of Chemistry, Faculty of Science and Environmental Studies, Universiti Pertanian Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.

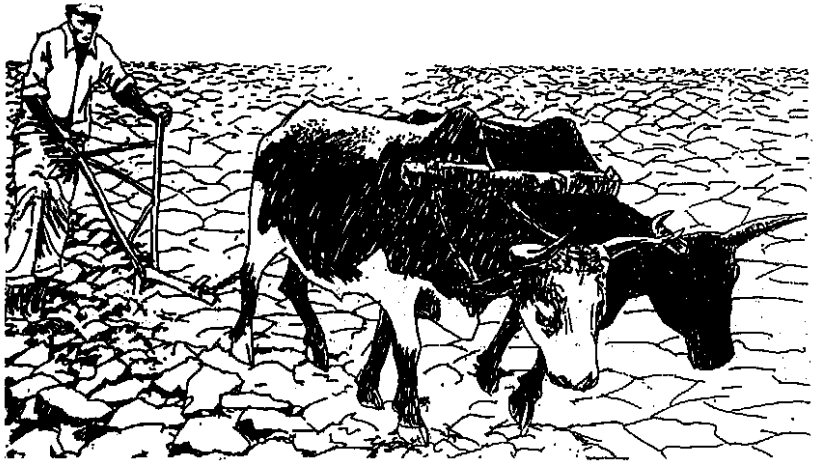
17-22 July 1994
The Future of Tropical Savannas: Managing Resources and Resolving Conflicts. Townsville, Queensland, Australia. Contact: Joel Brown, CSIRO-Davies, Laboratory, Private Mail Bag, P O Aitkenvale, Queensland, 4814, Australia.

20-26 August 1994
INTECOL's VI International congress of ecology. "Ecological progress to meet the challenge of environmental change". Manchester, UK. Contact: The Secretary, VI International Congress of Ecology, Department of Environmental Biology, University of Manchester, M13 9PL, UK.

November/December 1994
3RD International Course on "Fodder Tree Legumes - Multipurpose Species for Agriculture". Queensland, Australia. Comprises a six week program of lectures and field inspections examining aspects of *Acacia aneura*, *Leucaena leucocepala* and CSIRO & QDPI research programs. Contact: Fodder Tree Legumes, Course Secretariat, Department of Agriculture, The University of Queensland, St Lucia, Queensland, 4072. International telephone: 61 7 365 2062. International fax: 61 7 365 1188.

14-19 May 1995
IAWQ conference on river basin management. Kruger National Park. Contact: Dr Ben van Vliet, Watertech, CSIR. Tel (012) 841-2237 or Fax (012) 841-4785.

23-28 July 1995
5th International Rangeland Congress. Salt Lake City, Utah, USA. Contact: General Secretary, Vth IRC, PO Box 11 637, Salt Lake City, UT, USA 84 147.



FIRST ANNOUNCEMENT

SECOND SYMPOSIUM
DEVELOPING AREAS BRANCH
GRASSLAND SOCIETY OF SOUTHERN AFRICA

PEOPLE, RANGELANDS AND DEVELOPMENT

23 - 35 March 1994

Maseru, Lesotho

For details contact:

Grant Hatch
Department of Grassland Science
P.O. Box 375
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THE XVII INTERNATIONAL GRASSLAND CONGRESS, held in New Zealand and Queensland, Australia in February 1993, brought together 1500 delegates from over 90 countries under the theme "Grasslands for Our World". It provided a forum for reviewing the World's grasslands, their importance to food production for mankind and the maintenance of land and environmental resources, and recent progress and future prospects for developments in productivity and sustainability of grassland systems.

"Grasslands for Our World" brings together in a single volume the keynote and main session invited papers together with precis of the resulting discussions of each session.

The emphasis of the congress was on the technical and socio-economic factors influencing production in both developed and developing countries, with particular attention being paid to problems of production and resource stability in developing countries.

The five keynote addresses by world authorities embraced topic areas of:

- The World's Terrestrial Ecosystems
- Grasslands for Our World
- Grasslands for Sustainable Ecosystems
- High Technology for Our Grasslands
- Science and Information for Our Grasslands

Fifty main session topics were each covered by two invited papers, also from leading world authorities, covering contrasting or complementary approaches to developing and developed world regions. The main session topics included:

- Sustainability and Stability
- Biodiversity
- Climate Change
- Molecular Biology
- Socio-economics
- Technology Transfer
- Population Pressures
- Farmer (user) Requirements
- World Trade Issues
- Soil, Plant and Animal Sciences

The congress format stimulated discussion and the sharing of ideas, experiences and research findings. Each of the 50 discussion sessions was chaired by an authority on the topic. Precis of these discussions are therefore included in the publication together with the invited papers, to provide complete, authoritative statements on each session topic.

This book is therefore a challenging appraisal of the importance of grasslands and grassland production systems in the modern world. It will also provide unique and invaluable resource material on the current status and future priorities for the planning and resourcing of research and development in pastoral sciences and related interests.

As the next 10-20 years will be critical to the future of the World's grasslands and those who depend on them, this publication will for many years to come be obligatory reading for policy makers, technologists, economists, sociologists, and students training in all aspects of grassland sciences.

The book will be produced in hardcover A4 size with a full colour cover. It is expected to be available for sale from November 1993. We have already had expressions of interest for some 500 copies by organisations whom we expect will commit orders for the same quantity once the book is published.

To assist us with assessing a print run size we would appreciate completion of either the Order form or the Expression of Interest form below.

Proceeds from the sale of the book will be invested in the New Zealand Grasslands Memorial Trust and the Australian Howard Memorial Trust for progressing research in grassland sciences.

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