TIME	TITLE	AUTHOR/S
SYMPOSIUM: Linking Plant-Herbivore Interaction Theory to Management of Rangelands (Session Chair: Susi Vetter)		
09:20-10:00	*Keynote Address II:* The human dimension of rangeland ecosystem management	***Urs P Kreuter***
10:00-10:40	*Keynote Address III:* Behaviour-based grazing management for herbivores and ecosystems	***Fred D Provenza***
11:00-11:20	Browse responses to herbivory: how far have we come in 30 years?	***Peter F Scogings***
11:20-11:40	Behavioural and physiologic responses of herbivores to phytochemical defence	***Luthando E Dziba****, Xavier Manteca and Fred D Provenza*
11:40-12:00	Patches in space and time: how domestic herbivores utilise arid rangelands	***Adrian M Shrader****, Graham I H Kerley, Burt P Kotler and Joel S Brown*
12:00-12:20	Applications of plant-herbivore theory to the management of woody plant encroachment	***David Ward***
12:20-12:40	*General Discussion:* Applications of the theory on plant-herbivore interactions to the management of rangelands	*Facilitated by session chair,* ***Susi Vetter***

SYMPOSIUM: Linking Plant-Herbivore Interaction Theory to Management of Rangelands

SESSION CHAIR: DR SUSI VETTER

Platform Presentations & Discussion

The physical and biological complexity inherent in savanna ecosystems increases the productivity, diversity and stability of these systems. This complexity is not only important for ecosystem function, but it has profound influence on the productivity of animal populations that depend on these systems. While in the past much emphasis has been placed on physical defences of woody plants in savannas, there is now clear evidence that biochemical interactions among nutrients and toxins have an even more important role in influencing the value of foods items to animals. Varied meal patterns stimulate forage consumption and encourage animals to more fully use the range of plants available. However, when choice is limited because plants that contain toxins dominate the landscape, forage consumption may decline with negative consequences for production. Increased diversity enables individual animals to select diets and food patches that allow them to meet their needs. This symposium will explore how grazing can be designed to stimulate foraging and enable animals to optimize nutrient intake while regulating intake of various plant secondary compounds. We will also discuss implications for animal performance and production and for sustainable management of rangelands, especially rangelands that are severely affected by bush encroachment where less palatable and chemically defended plants are more likely to dominate.

KEYNOTE ADDRESS II

THE HUMAN DIMENSION OF RANGELAND ECOSYSTEM MANAGEMENT

Urs P Kreuter

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Rangeland ecosystems are spatially extensive and they deliver goods and services upon which all human societies depend for survival. The continued delivery of these goods and services is contingent upon the retention of the integrity of ecological processes that generate these goods and services. Therefore, ecologists have long emphasized the “protection” of ecosystems from human impacts. This suggests that people are apart from and not integral to ecosystems. Yet,

human impacts on ecosystems are difficult to "control" and impossible to eliminate. For the survival of human society and of other species that require habitats affected by human activities, human behavior as a pervasive agent of change cannot be ignored. Rather human incentives need to be harnessed in order to enhance rather than diminish ecosystem productivity.

To develop this thesis, the presentation will address six issues: (1) The three legs of sustainable ecosystem management: ecological soundness, economic feasibility and social acceptability; (2) Why the social dimension of resource management has historically been discounted; (3) Why management at the ecosystem and landscape scale is becoming increasingly necessary in the face of growing human population pressure on natural resources; (4) How the application of large scale management necessitates the inclusion of multiple stakeholders and decision makers; (5) The necessary factors for effective ecosystem management and how human behavior can be harnessed to facilitate integrated, large scale management; and (6) How human the value of ecosystem services that are not traded in the market place can be estimated (e.g., contingent valuation and contingent choice methods). The presentation will also provide three case studies in which human incentives have been successfully integrated in ecosystem management. The presentation will conclude with recommendations for improving the effectiveness of integrated rangeland management at the ecosystem scale.

KEYNOTE ADDRESS III

BEHAVIOUR-BASED GRAZING MANAGEMENT FOR HERBIVORES AND ECOSYSTEMS

Fred D Provenza

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Once understood, behavioural principles and processes can be transformed into practices that provide an array of solutions to challenges people face in attempting to manage landscapes for the well being of the many species of plants and animals that depend upon them. Unlike the infrastructure of a ranch such as kraals, fences, and water development, behavioural solutions cost very little to implement, they are not fossil-fuel intensive, and they are easily transferred from one situation to the next. In the case of grazing, behaviour-based management is increasingly attractive given growing economic and environmental concerns with fire, herbicides, and mechanical means of rejuvenating landscapes. While we have learned much during the past three decades about how genes interact with social and biophysical environments to create foraging behaviors, scientists and managers remain generally unaware of the power of behaviour to transform ecosystems, despite compelling evidence. The issue isn't if creatures are adapting to ongoing changes in social and biophysical environments, they do so every day of their lives. The only question is whether or not people want to participate in the process. If so, behaviour-based management offers opportunities, for example, to use understanding: 1) of the relationship between palatability and plant biochemistry to rejuvenate landscapes to benefit wild and domestic animals, 2) of the importance of variety in the diet and daily grazing sequences of livestock to enhance wildlife benefits to land owners, managers, and users, and 3) of the value of biochemical complementarities for developing plant mixes for pastures that provide a full range of benefits - nutrition and health for plants, herbivores, and people - without the unsustainable costs associated with fertilizers, herbicides, insecticides, antibiotics and anthelmintics.

BROWSE RESPONSES TO HERBIVORY: HOW FAR HAVE WE COME IN 30 YEARS?

Peter F Scogings

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"... browsing is predicted as a consequence of animal size ... and availability of forage ... defoliation impacts are levied simply as reduction in plant part biomass ..." - a description of the browse-browser component of a model of semi-arid savannas.

Woody plants provide important nutrition for many ruminants in savannas, but knowledge of the interactions between browsers and browse is minimal. With the objective of providing

direction for research on browse-browser interactions in savannas, I analysed research trends over three decades and summarised the state of knowledge, highlighting strengths and weaknesses in browse-browser research in savannas. Emphasis was placed mostly on browsers other than African elephant, for which a large body of knowledge exists. Numbers of papers published per decade have increased, and the trend is continuing. Studies have become more multivariate. For most woody species, especially *Acacia* species, summer browsing stimulated browse production, except at the beginning of the growth season. Winter browsing had no effect, which contradicts observations in boreal systems. Infrequent browsing stimulated shoot production, but frequent browsing did not, while prolonged browsing reduced plant growth and survival. After cessation of browsing, stimulated shoot production normalized sooner than plant growth. Increased spinescence accompanied changes in shoot morphology and demography. In many cases, changes in nutritional quality were undetected, but when changes occurred, they were variable. Deciduous species inconsistently reduced quality, but evergreen species consistently did otherwise. Increased tannin concentrations in some deciduous species were related to browsing intensity, while reduced concentrations were not, but reductions persisted longer than increases. Repeated browsing reduced canopy cover long before plant populations were affected, while communities were inconsistently altered. Browsing seldom caused direct mortality of plants. Seedlings were most sensitive to decapitation below the cotyledons or when switching nutrient source from cotyledons to roots. Otherwise, seedlings tolerated browsing more than drought. Broad deficiencies are in non-*Acacia* species, wildlife impacts and physiological responses. Little is known of belowground responses, N-rich secondary metabolites, seed production and clonal propagation. High variation in field experiments has often prevented detection of significant effects. Inconsistent support for accepted models indicates that substantial new research is needed before robust models of browse-browser-resource interactions can be developed for savannas. Multi-factorial experiments aimed at understanding physiological functioning of whole plants and the dynamics of populations in response to browsing and resources are required. For now, the browse-browser component of savanna management models remains unconvincing.

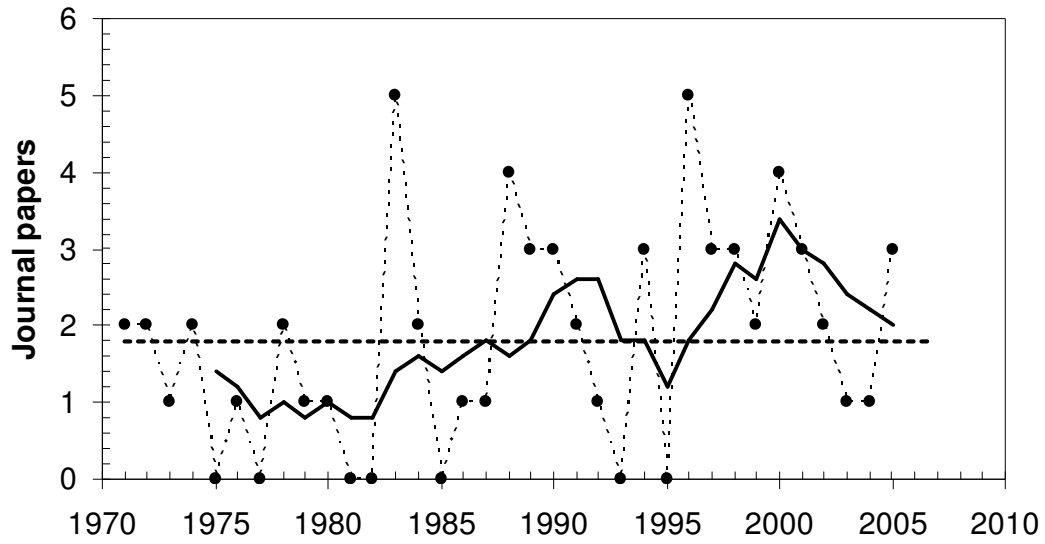

Figure 1: Number of peer-reviewed journal papers on ruminant impacts on woody plants in African savannas, 1971-2005. Horizontal dashed line – 35-year mean. Solid line – 5-year running mean.

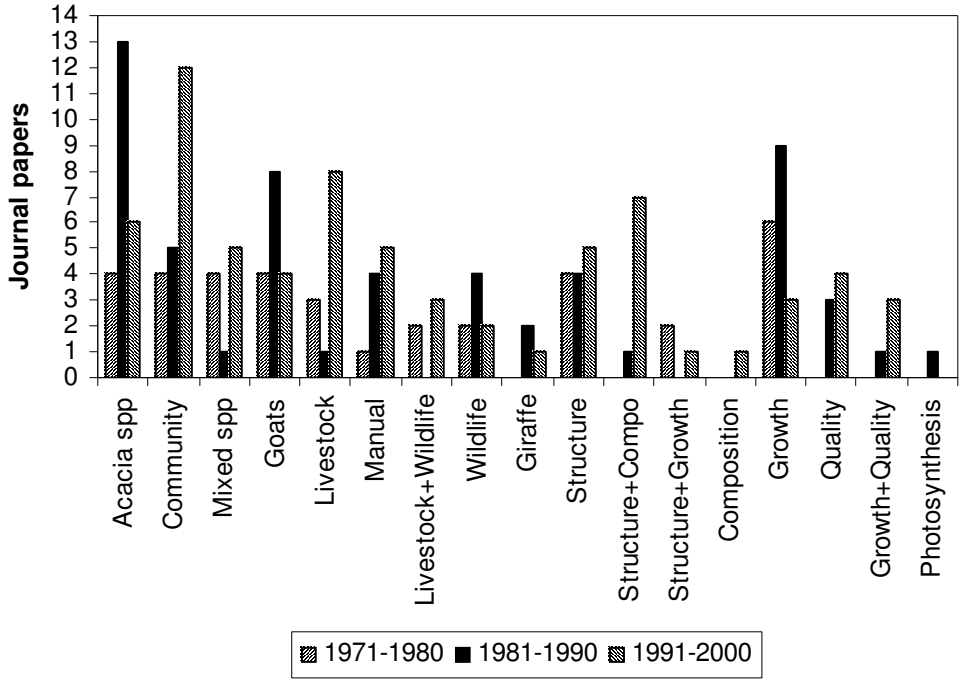

Figure 2: Number of peer-reviewed journal papers on ruminant impacts on woody plants in African savannas, 1971-2000, per decade within three plant categories (far left), six animal categories (left of centre) and eight response categories (right)

BEHAVIOURAL AND PHYSIOLOGIC RESPONSES OF HERBIVORES TO PHYTOCHEMICAL DEFENCE

Luthando E Dziba[1*#], Xavier Manteca[2] and Fred D Provenza[3]

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Herbivores have behavioural and physiological means for coping with toxins in forage plants. Understanding the relationship between physiology and behaviour is vital for understanding countermeasures herbivores use to mitigate toxicity from overingesting phytochemicals from the various plants they consume. I report on the feeding behaviour and physiological responses of lambs in various trials conducted with sheep in response to sagebrush monoterpenes. In one trial, we infused one group of 4 lambs intravenously with 40 mg kg^{-1} BW camphor, 1,8-cineole, and p-cymene mixed in intralipid. In another trial, we dosed another group of 4 lambs intraruminally on two consecutive weeks with a single-bolus dose of 125 mg kg^{-1} BW camphor, 1,8-cineole, and p-cymene mixed in vegetable oil. For both trials, we monitored changes in blood pH, clinical effects and feeding behaviour. During intravenous infusions, dosed lambs stopped feeding sooner than control lambs ($P<0.05$). Lambs began feeding again soon after the infusions stopped, which was consistent with the rapid rates at which these compounds were eliminated from the body. Ruminally dosed lambs stopped feeding sooner than control lambs ($P<0.05$). In summary, systemic concentrations and rates of camphor elimination influenced feeding behaviour, but lambs displayed behavioural and physiologic responses that enabled them to counteract the toxic effects of camphor. I conclude by drawing inferences from local examples based on known characteristics of chemically defended plants.

PATCHES IN SPACE AND TIME: HOW DOMESTIC HERBIVORES UTILISE ARID RANGELANDS

Adrian M Shrader[1*#], Graham I H Kerley[1], Burt P Kotler[2] and Joel S Brown[3]

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In arid rangelands, domestic herbivores contend with a wide range of factors that influence their foraging. These may include plant secondary compounds, water availability, time of day, herd size and predation risk. To determine the relative importance of these different variables for goats living in a semi desert, we measured foraging effort (giving up densities - GUDs) in artificial food patches. Our approach allowed us to quantify and rank the effects that disparate environmental factors had on the goats' foraging costs: water > time of day > herd size > plant secondary compounds. This demonstrates how the provision of water may increase grazing impacts at the patch scale by herbivores. In contrast to observed elevated impacts around water points, goats forage more intensively at increasing distances from water. The effects of water therefore differ at patch and landscape scales. In response to predation risk, goats did not forage across landscapes uniformly. Our results indicate that despite selection during 10,000 years of domestication, free-ranging domestic herbivores still forage in 'landscapes of fear'. Our findings challenge the notion that domestic herbivores use landscapes homogeneously in space and time. Results thus indicate that GUDs can be used to better predict and manage herbivore impacts across landscapes.

APPLICATIONS OF PLANT-HERBIVORE THEORY TO MANAGEMENT OF WOODY PLANT ENCROACHMENT

David Ward

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Bush encroachment affects the agricultural productivity and biodiversity of 10 to 20 million hectares of South Africa. Many people believe that we understand the causes of bush encroachment. Belief in grazing as the sole cause of bush encroachment stems from Walter's two-layer model. This model states that grasses typically out-compete trees in open savannas by growing fast and intercepting moisture from the upper soil layers, thereby preventing trees from gaining access to precipitation in the lower soil layers where their roots are mostly found. When heavy grazing occurs, grasses are removed and soil moisture then becomes available to the trees, allowing them to recruit en masse. However, bush encroachment is widespread in areas where there is a single soil layer and where grazing is infrequent and light. Bush encroachment occurs in many arid regions where fuel loads are insufficient for fires to be an important causal factor. If we are to understand the causes of bush encroachment, we need mechanistic models to guide us and multi-factorial experiments to tease out the interactions among causal factors. Variations on David Tilman's resource ratio models, as well as some spatially-explicit models, appear to hold great promise in this regard. Field experiments carried out to date show that support for grazing and fire as causes of bush encroachment is not convincing, and that rainfall amount and frequency, coupled with specific soil nutrient levels, may drive this phenomenon. Nitrogen fixation may also be important for an encroaching species, *A. mellifera*, when grasses are present. We have also shown that competition between two encroaching species, *A. mellifera* and *Tarchonanthus camphoratus*, can be important. Dominance of *T. camphoratus* over *A. mellifera* occurs when *A. mellifera* is removed.