Northern plains programme

FOR MOPE INFORMATION CONTACT:

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OBJECTIVES OF THE NORTHERN PLAINS PROGRAMME

The Northern plains programme uses the northern basalt plains and the area north of the Olifants as an intensive study site to examine the ecosystem effects resulting from interactions between the most important system drivers; - rainfall/climate, soil fertility/nutrients and herbivores with management actions such as the provision of additional water, fire and fences. The intention is to highlight the links between rare biota [specifically scarce antelope that are rare in the Kruger National Park (KNP)], habitat diversity, biodiversity and ecosystem function and processes. The product of this programme will be a significant strategic contribution to link understanding of ecological processes to rare biota and biodiversity conservation and thus help to understand how the system supports, or fails to support, specific biota.

For the next five years this programme intends to specifically concentrate on the effect of the provision of additional permanent water on the ecosystem, exemplified by changes in overall biodiversity. The decline in the rare antelope is hypothesised to be at least partly due to changes associated with water provision, thus this aspect will also be addressed in this study.

This programme is based on the updated objectives hierarchy (as developed by the end of 2003) specifically addressing aquatic and terrestrial objectives (Appendix 1).

RESEARCH AND FIELD WORK OPPORTUNITIES

RARE ANTELOPE

We specifically need research on habitat and food preferences of Tsessebe in the KNP, both in enclosures and free animals.

Thus far no new research has been initiated on the tsessebe, and there is still concern about the losses incurred when darting them.

The scientists from Zimbabwe that came to do the Tsessebe study here in 2001 have now published their findings (Dunham *et al.* 2003) (available as a pdf file from Guin Zambatis). Tsessebe number and age structure was used to determine year-to-year variation in adult survival. Adult survival rate was positively correlated with dry-season rainfall (a measure of grass productivity during the dry season) and with the cumulative rainfall surplus (seasonal rainfall above the average). Juvenile survival rate (as indexed by the juvenile:female ratio) was also correlated with the cumulative rainfall surplus.

Adult survival rate was density-dependent, indicating that there was intraspecific competition for food. When the relationships between survival rates and rainfall were used in a model of tsessebe population dynamics to predict juvenile and adult survival rates from the recorded annual and dry-season rainfalls, the modelled population changes were similar to those observed. The conclusion was that the drop in tsessebe numbers was probably due to rainfall-induced changes in food availability during the dry season, which led to a decline in adult survival rates after 1986.

The principal management implication of these findings is that the tsessebe decline can be reversed only by several successive years of above-average annual rainfall. Green grass during the dry season is a key resource for survival, not only for tsessebe, but also for other African antelopes that graze selectively. Competition for this resource will thus be to the detriment of these antelope.

. Total number of tsessebe according to ranger estimates between 1999 and 2003 indicate a possible slight increase towards 2003.

WATER PROVISION

The Transfrontier Transect – learning jointly about effects of wildlife management regimes across Africa's prime wildlife area

The protected areas of the eastern and central Lowveld and escarpment and the Mozambique transfrontier zone form this transfrontier ecosystem. This region supports one of the most diverse large mammal populations found in any subregion in the word, and covers an area of about 4 000 000 ha. The largest part of this area is covered by the Kruger National Park (KNP) of 2 000 000 ha and the Limpopo National Park in Mozambique of 1,000,000 ha. This area is variously managed as national park, provincial nature reserve, private reserve, wilderness, resource area and state land. These management regimes vary from "hands off" in most of the Limpopo Park to very intensive management of wildlife in the private game reserves, with the Kruger National Park in between.

Fences separating different land uses have changed animal migration patterns while the proliferation of artificial water points has altered the mammal and plant species composition and distribution. When goals for park management are set, we strive to rehabilitate conservation areas to what it was in its pristine state. However, it is very difficult to determine what this state could be. The newly created Limpopo National Park, is such an almost pristine area, and thus provides a unique opportunity to measure the long-term effect of the different management regimes utilized in the Kruger National Park, adjacent private reserves and resource areas.

Such a large scale programme as the one envisaged here is difficult to run due to a shortage of skilled people in this specialised but increasingly important field. This project thus also provides an opportunity to funders to contribute to building capacity in this growing field.

The proposed project will be aimed at delivering two major products:

- An improved understanding and knowledge about the effect of management (fire, fencing, water provision etc.) on the ecosystem and on sustainable resource utilization

- Increased capacity in the form of scientists and technicians for monitoring of natural resources.

Study area

The following areas will form part of the study area:

- The Wildlife sanctuary in the Limpopo National Park
- The Limpopo National Park
- The Kruger National Park
- The Timbabvati and Klaserie private reserves
- Mariyeta Resource area between Thohoyandou – Punda Maria road and the Letaba river

Working procedure:

The surveys will cover the following

- Select suitable survey sites
    - This will be done by an experienced team that will include representatives from all the management regimes
    - Sites will represent management and land use regimes, geological and climatic gradients and landscape differences (upland & lowland sites).
- Plant species surveys; woody and herbaceous
- Biodiversity surrogate surveys as developed by KNP researchers
- Landscape function assessment
- Species surveys

This Project will deliver:

- Scientifically based recommendations for long-term wildlife management in the Lowveld at different scales and management intensities
- An improved understanding of the system resilience to management procedures and resource utilization
- A trained team for future monitoring of natural resources.
- A baseline that could be used to detect long term change in biodiversity and system function
- If this project is successful it can be incorporated in the training of conservation students and will thus improve capacity to successfully implement and monitor the new Biodiversity bill in other parts of the country.
- Information brochures with a description of the project and the main findings to be distributed in all the protected areas to the general public (these could be used the flagship to acknowledge the sponsoring agency and make the public aware of their support).

- Opportunities to contribute
    - Thesis looking at a specific aspect or area
    - Help with surveys for a specific time period to gain experience
    - Part of study project with a small study that will contribute to the overall study.
- Funding

  At this stage no funding is available, we can only help with cheap accommodation.

RESEARCH RESULTS

These projects provide important background on the ecosystem and ecosystem function with two projects specifically aimed at improving our knowledge and understanding of the requirements of sable and roan antelope. Studies on the effect of herbivores on the vegetation structure and composition as well as the interaction between herbivores and water provision will address specific research objectives of the KNP (Appendix 2). This information will provide guidelines towards the distribution of waterpoints and the effects it may have on animal composition.

RARE ANTELOPE STUDIES

THE FORAGING ECOLOGY OF ROAN ANTELOPE

This was examined by Marie-Claire Knoop. Grazing by the roan in the dry season of 2001 and 2002, was estimated using three measures: the proportion of quadrats showing grazing, the difference between the grazed and the ungrazed heights, and the proportion of tillers removed per tuft of grass.

The overall trend indicates that there was more grazing within the bottomlands than within the uplands in the dry season of 2002, with grasses in the bottomlands remaining green longer than those in the uplands. Tufts that had been previously grazed were more often reutilized in the bottomlands. The combined index of grazing shows that, overall, the signs of grazing in the bottomlands was greater than the signs of grazing in the previous year.

The grass species that were most utilized by the roan during the dry season.roan were *Sporobolus pyramidalis, Ischaemum afrum* and *Panicum maximum*. The proportion of quadrats showing grazing exceeded 40% by June 2002 for six species (*Ischaemum afrum*, *Schmidtia pappophoroides*, *Sporobolus pyramidalis*, *Panicum maximum*, *Themeda triandra* and *Panicum coloratum*), whereas *Sporobolus pyramidalis* was the only species showing grazing in excess of 40% of quadrats by August 2001. In this study it would appear that *Panicum maximum* and *Sporobolus pyramidalis* were preferred grass species, *Ischaemum afrum* and *Panicum coloratum* were less-preferred grass species, and other species, like *Sporobolus ioclades*, *Schmidtia pappophoroides* and *Setarria incrassata,* were not utilized much. *Themeda triandra* showed little signs of grazing in 2001, but was moe utilized in 2002.

The faecal nitrogen level was slightly higher during July and August 2002 than the corresponding period in 2001. The higher nitrogen level was perhaps a reflection of the browsing by the roan that was observed during this time. By the end of August 2002, there was a very distinct browse line within the enclosure.

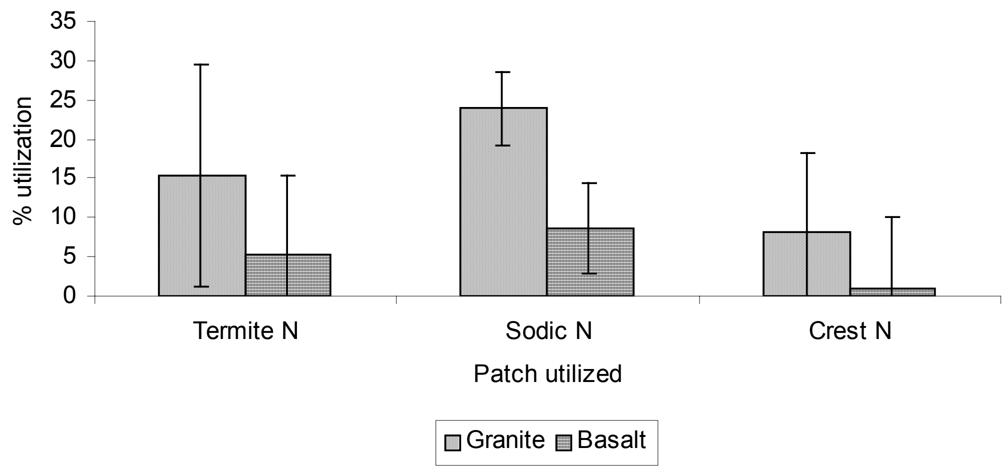
The conclusion of the study is that the bottomlands in the enclosure act as a key resource area for the roan during critical dry periods.

MULTI-SCALE NUTRIENT PATTERNS INFLUENCING MAMMALIAN HERBIVORE DISTRIBUTION.

This study on the undertaken by Rina Grant. The average herbivore biomass on the northern basalt plains between 1980 and 1993 was 23 $kg.ha^{-1}$ which is lower than the 29 $kg.ha^{-1}$ on the northern granites. However, the average herbaceous biomass between 1991 and 1999 of 3646 $kg.ha^{-1}$ was higher on the northern basalts than the 1766 $kg.ha^{-1}$ on the northern granites.

Tuft utilization was higher on the granites than the basalts with more utilization on the sodic sites and termite mounds even in the basalts (Fig. 8).

Fig. 8. Percentage utilization of grass tufts in three different forage patches on the granites and basalts in the area north of the Olifants river.



Foliage was collected seasonally from the forage sites to see whether forge nutrients could explain the forage preferences.

On the nutrient-rich basalts, termite mounds had the highest nutrient content. On the granites, sodic sites and termite mounds supported forage with much higher nitrogen and sodium concentrations than the crests (Table 6). The higher animal numbers on the northern granites can thus not be explained by plant nutrients or forage biomass. However, the higher animal numbers on the granites may be explained by the fact that a much larger area is covered by the more nutrient rich sodic patches in the granites (Mathys, 2001) (Table 5). Termite mounds are also more abundant on the granites ({Meyer, Braack, et al. 1999).

Table 5. Area covered by sodic patches (using data from Lucas Matthys) in the granites and basalt relative to the size of the land system in the area north of the Olifants river.

	Total area	Basalt in ha	Granite in ha
Sodic	2642.558	493.74	1932.3
Land system	841342.6	341885.2	499457.43
% sodic	0.314088	0.144417	0.386879819

Table 8. Foliar nutrient content of grasses in three different types of forage patches in the area north of the Olifants river

Factor	n	Total N %	% P	% Mg	% Ca	% K	% Na	C:N ratio
Termite basalt N	5	1.78 ± 0.17	0.38 ± 0.03	0.21 ± 0.02	0.62 ± 0.06	2.56 ± 0.18	0.32 ± 0.14	19.3 ± 5.25
Termite granite N	3	0.90 ± 0.23	0.24 ± 0.04	0.33 ± 0.04	0.50 ± 0.08	1.72 ± 0.25	0.21 ± 0.20	38.56 ± 1.93
Sodic basalt N	9	0.93 ± 0.13	0.26 ± 0.02	0.23 ± 0.02	0.53 ± 0.04	1.15 ± 0.14	0.50 ± 0.11	43.1 ± 4.05
Sodic granite N	8	0.98 ± 0.13	0.17 ± 0.02	0.20 ± 0.02	0.42 ± 0.04	1.01 ± 0.15	0.86 ± 0.12	41.4 ± 4.23
Crest basalt N	7	0.88 ± 0.14	0.29 ± 0.02	0.21 ± 0.02	0.49 ± 0.05	1.78 ± 0.15	0.19 ± 0.12	44.5 ± 4.44
Crest granite N	5	0.79 ± 0.16	0.23 ± 0.02	0.28 ± 0.02	0.50 ± 0.06	1.77 ± 0.18	0.13 ± 0.14	59.2 ± 5.22

Highest values in bold ± standard error.

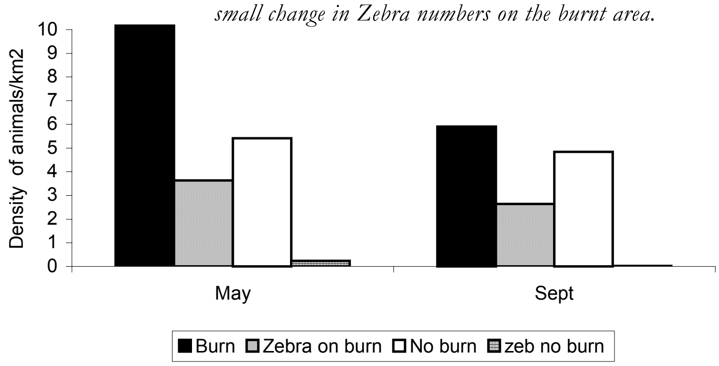
At this point it is postulated that the higher number of herbivores in the granites may be associated with the larger area of nutrient-rich sites. We hope to initiate a project that would look into this more intensively.

If these sites are as important in providing essential nutrients during the growth season to build up body reserves as we postulate, then the competition for the small area of high nutrient forage could have been one of the factors leading to the decline in the roan antelope.

THE EFFECT OF LARGE AREA BURNS ON NUTRIENTS AND HERBIVORE DISTRIBUTION.

This study was done on request of Johann Oelofse, Section ranger at Mooiplaas after an area of 113.38 km^2 around the Capricorn camp burnt down in April 2002. Within a week there was a rainfall event of about 20 mm. Soon after, zebra that had been almost absent from the area, were seen on the burnt patch. To determine the effect of a burnt patch on the concentration of herbivores, the animals on the burnt patch and an unburnt control area of 228.87 km^2 was counted in May, using a fixed wing aircraft. These counts were repeated in September of 2002 (Fig. 10). The density of animals was much higher on the burnt area within the first month after the burn, but animals were distributed almost evenly by September. However, most of the zebra that moved on to the burn in May were still there in September.

Fig. 9 A comparison of animal numbers on burnt and unburnt areas one month after the burn ad again 4 months later , indicating the small change in Zebra numbers on the burnt area.



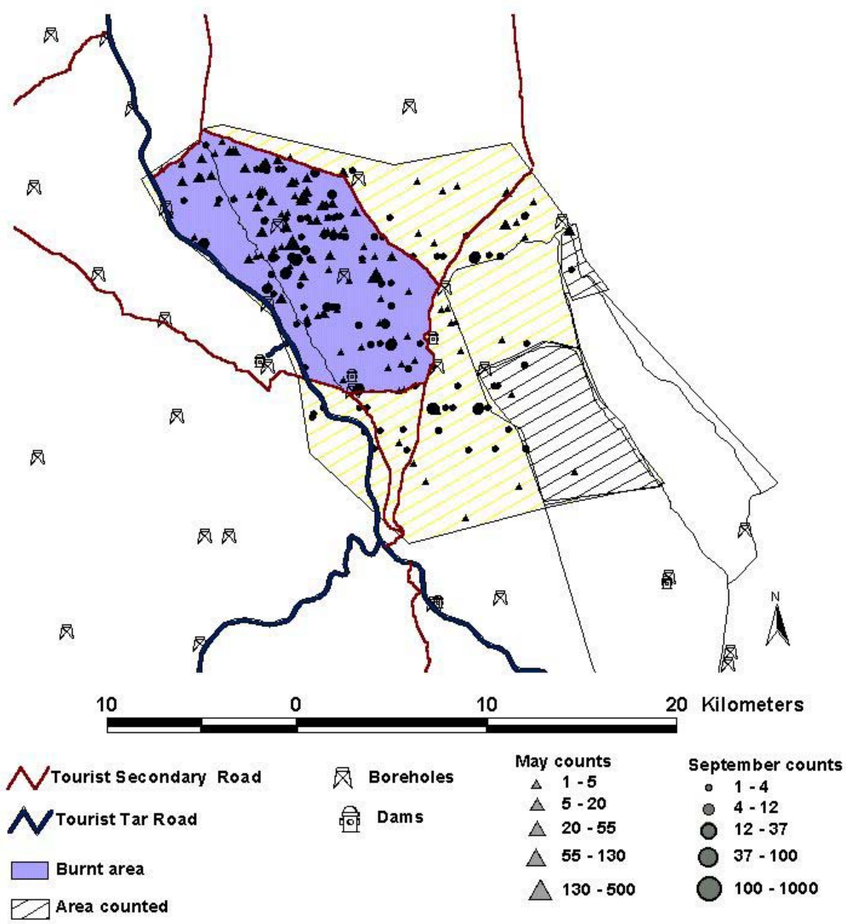
Grass samples were collected in May to test whether the nutrient content of grass in the burnt and unburnt areas differed. The nutrient concentration in the grass in the burnt area was much higher than that of the unburnt area, which probably explains why animals prefer burnt patches were there Table 7.

Table 7. Nutrient concentrations in grass collected in the burnt and unburnt area near Mooiplaas.

	Burn	**No burn**
Nitrogen %	2.21 ± 0.072	0.71 ± 0.072
% Protein	13.8%	4.43%
Phosphorus %	0.73 ± 0.026	0.13 ± 0.026
Sodium %	0.92 ± 0.036	0.14 ± 0.036

In all cases $p<0.0001$

Fig. 12 A comparison of animals on burnt and unburnt patches one month after the burn and again 4 months later, indicating the small change in zebra numbers on the burnt patch.



DIETARY PREFERENCES OF UNGULATES

Studied by Matt Sponnheimer's group. They showed that both faeces and hair data show strong dietary differences between impala from the northern and southern regions of the park ($p < 0.0001$), with southern impala grazing more than their northern counterparts. The faecal data suggest a diet of 41 % grass in the north and 63 % grass in the south. Similarly, the hair data suggest a 44 % grass diet in the north and 82 % grass diet in the south. The difference between the faecal and hair samples is that hair data represent a long-term dietary average, whereas the faecal data largely reflect the season when they were collected (the beginning of the dry season).

RARE UNGULATES LIKE ROAN AND SABLE ANTELOPE

Samples from these species also provided interesting results. Faecal data demonstrated that the Northern Plains roan eats grass nearly exclusively, and that their faecal nitrogen concentration (~0.8%) is lower than that of any other herbivore in KNP, including bulk grazers like zebra and white rhino. Similarly, sable appears as nearly an exclusive grazer, though our data indicate a notable increase in browse during October 2003. Sable also has very low faecal nitrogen concentrations (~1.0%), but not as low as those of their congener the roan.

MAPPING FORAGE QUALITY

This was the aim of Onisimo Mutanga's study. In order to achieve this objective, he had to develop techniques to predict and map the quality of tropical grasses at canopy level using hyperspectral remote sensing. In order to better understand the variation of the nutrients that were measured in the field, the possible factors influencing that variation at a local scale was established. The results indicated that there is a significant relationship between grass quality parameters and site-specific factors such as slope, altitude, percentage grass cover, aspect and soil texture (Table 10).

Table 8: Correlation coefficients (r) between macronutrients and continuous environmental factors (n = 91). For the relationship between macronutrients versus slope as well as aspect, sample plots with slope and aspect values greater than 0 were used.

	N	**Ca**	**K**	**P**	**Mg**	**Na**
Altitude	-0.44*	0.26*	0.30*	0.31*	0.04	-0.21
Slope	-0.72*	-0.71*	-0.57*	-0.23	-0.26	-0.65
Aspect	-0.62*	-0.14	-0.79*	-0.53*	-0.65	-0.60
DLs	-0.09	-0.23*	0.19	-0.05	-0.16	0.13
Cover	-0.29*	0.04	-0.51*	-0.23	-0.23*	-0.4*
Biomass	-0.24*	-0.20	0.14	0.08	0.06	-0.21

* Significant level: $p < 0.05$

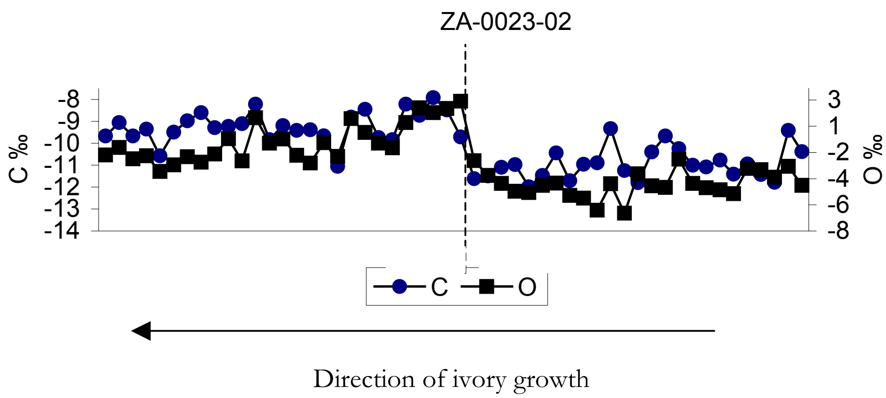
Plant characteristics such as species type interact significantly with slope, altitude and geology in influencing nutrient distribution. There is generally higher N concentration in the granites as compared to the basalts, however it interacts strongly with the amount of biomass. Therefore, multivariate analytical approaches will be important in explaining the effect of environmental variables on foliar quality.

This information will further help to identify areas that may supply the rare antelope with essential nutrients and thus improve our understanding of the factors that may have led to the decline in the rare antelope.

CHANGES IN ELEPHANT DIETARY HABITS

Jacqui Codron analyzed a number of transverse sections of ivory incrementally for stable carbon and oxygen isotope ratios. Carbon isotope ratios indicate that elephants have begun to consume significantly more grass in the northern regions of Kruger Park during the last several decades. In the southern regions, however, their grass/browse intake has remained relatively unchanged. These results were obtained from only a few individuals, and thus it is necessary to increase the ivory sample size, thereby creating a more robust data set, while increasing the time period for which dietary tracings can be inferred.

Fig. 13 *– Stable carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotope data obtained from incremental analysis of dentine carbonate of two transverse sections taken from tusk ZA-0023-02, of an animal that lived near Shingwedzi. $\delta^{13}C$ data show an increase in grass consumption by this individual between the 1960's and 1990's. The dates are an estimate based on observations of incremental growth lines on the internal surface of the ivory*



This change in diet of elephants almost coincides with the start in the decline of the roan antelope population. More samples obviously need to be tested before any conclusions are drawn, but this may prove to be very relevant to future ecosystem studies. The opposite pattern was expected as it has now been fairly well established that tree density would increase because of global warming. Work by Holger Eckard using fixed point photos in the KNP confirmed this hypothesis. Questions that arise from this are for instance whether the elephant changed to grass because of an increase in tannin levels in the browse. We hope to get a project looking at differences in phenolic compounds in northern Kruger and Tanzania that might help to understand some of these patterns.

PREDICTING NUTRIENT AND POLYPHENOLS AND TANNINS LEVELS IN WOODY VEGETATION

Jelle Ferwerda's project intends to ultimately produce a spatial model of the chemical composition (N, P, K, Ca, Na, Ca, Mg, tannins and polyphenols) of vegetation. Analysis of spatial patterns of the 2002 samples revealed a potential relation between soil properties and tannin content. This is currently being tested in a greenhouse in Wageningen.

This study does not feed directly into the aim of the northern plains programme, but if the phenols in the Mopane are very high, it may explain why the elephant utilize more grass in the north. It may also explain why the herbivore numbers are so low in areas where there are very dense stands of Mopane.

HERBIVORE INTERACTIONS AND WATER PROVISION

THE RESPONSE OF ZEBRA TO THE PATCHY DISTRIBUTION OF RESOURCES

Zebra responses to resources such as food, water and predator avoidence areas was examinded by Thereza Davidson. Zebra selected areas within a 5 km radius from water. They tended to avoid denser vegetatated patches at night but did utilize these patches during the day. Zebras selected *Eragrisits rigidior*, *Urochloa mosambicensis* and *Panicum maximum* when resources were plentiful, but were not very selective when resources were scarse.

The results of this study suggests that zebra were present around permanent water points, especially those in open areas. Most of the waterpoints were in or near drainage lines, which provide forage during the critical dry periods (see Knoop this report). Even though their species preference differs from that of roan, the zebra would utilized the same forage when resources were scarce. A decrease in available forage which would have caused the rare antelope to be a poorer condition then if they were absent, making the rare antelope more vulnerable to predation and disease during drier years.

CHANGES IN VEGETATION AROUND PERMANENT WATERPOINTS

Izak Smith used satellite imagery integrated into a Geographical Information System for this study. Only three waterhole were examined, one in the granites, one in the basalts and one at the intersect of the basalts and granites. The data suggested that most grazing impacts on vegetation cover occurred within a 2 km zone around waterpoints on the granitic soils and up to 3 km around waterpoints in the basaltic ecozones. These findings imply that the provision of artificial water could lead to more homogenisation on the nutrient-rich basaltic soils than on the granitic soils. However more waterholes in the different land systems and in different rainfall zones should be examined before such a conclusion can be made.

THE RESPONSE OF HERBACEOUS VEGETATION TO SELECTIVE AND HIGH DENSITY BULK GRAZERS

Abri de Buys compared the vegetation inside the N'washitshumbe enclosure that had only been utilized by selective grazers with the outside that had been intensely utilized by zebra and buffalo. In 2002 when the survey was done, the animal biomass inside the enclosure was about 37.5 $kg.ha^{-1}$ compared to about 20.2 $kg.ha^{-1}$ outside. Of the animal biomass outside, zebra contributed 22% and buffalo 48%. Palatable perennials (decreasers) formed a significantly higher percentage of the grass sward inside the enclosure than outside (p=0.0041), in spite of the higher herbivore biomass inside. The vegetation biomass did not differ significantly (p=0.19) with 6.9 ± 3.5 ton/ha outside compared to 6.3 ± 3.5 ton/ha inside, but species composition did (Table 9).

This study implies that the provision of a higher density of waterpoints is not only beneficial to the water dependent grazers, but also leads to an associated change in vegetation. This is seen as a change from a decreaser dominated sword, preferred by selective grazers, to an increaser dominated sword that can be more efficiently utilized by the bulk grazers.

Table 9. Comaprison of grass species recorded inside and outside the N;washitshumbe enclosure.

Type of grass	% of grass sward inside enclosure	% of grass sward outside enclosure	p	n
Decreaser	59.8 ± 3.9	38.8 ± 3.9	0.0015	24
Increaser II	31.1 ± 3.9	47.7 ± 3.9	0.013	24
Urochloa mocambiscensis	9.7 ± 4.2	14.8 ± 4.0	0.29	20

THE EFFECT OF WATER PROVISION ON OF BIODIVERSITY

To understand the effect of the provision of additional permanent water on the ecosystem and biodiversity is the focus of the northern plains research programme. To achieve this objective, a survey method for biodiversity had to be developed for the northern plains study site. Chris Margules from the CSIRO, who is a leader in the biodiversity field, came to help with the selection of representative survey sites (Margules et. al. 2003).

Biodiversity surveys are based on the presence or absence of a species along a representative group of transects. As this approach is very resource intensive for smaller biota such as smaller vertebrates and invertebrates, a habitat component approach was developed by a team of KNP researchers. This data would act as surrogate for the biota and should give a good indication of which species should be present or absent in a transect with specific habitats. This approach was tested on the northern plains using the Cyber Tracker system for data capturing.

To test the technique, tree species were surveyed along 81 transects representing 12 environment domains. Results from this preliminary survey are presented to indicate the type of information that can be obtained from these surveys (Fig. 12 a-d). Obviously many more transects will have to be surveyed before any conclusions can be drawn. The Shannon diversity index was tested in an ANOVA to determine whether the sample data could detect any significant differences in diversity between the basalts, granites, sandveld and karoo sediments. However, no differences were found.

After good rains in October 2003, Andrew Deacon did a survey at Shirombe in the Nwambiya as a ground-truthing exercise for the biodiversity surrogate survey. Three transects of 100 m each were done per catenal sequence (valley bottom, footslope and crest (due to the flat topography, no midslope was discernable). The results indicated that using habitat components as surrogates for the small vertebrates, was successful as species found concurred with what was expected from the desktop study. Only reptiles, frogs and rodents were surveyed as part of the exercise and emphasis was placed on tree structure, which will feed into the bird monitoring later. Twelve reptiles, four rodents, one elephant shrew, and five frog species were encountered on the 900m of transects. This relatively large, small vertebrate diversity support the method used thoroughly and the confidence rating will just increase as more sampling is done. Although the sandveld was easy to sample (low grass cover, early in season, good rain), it is not anticipated that other land types will not deliver similar positive results. It is concluded that the habitat surrogate method will prove to be a very reliable technique for rapid biodiversity surveys in the large area covered by the KNP.

PRELIMINARY RESULTS FROM OTHER SURVEYS:

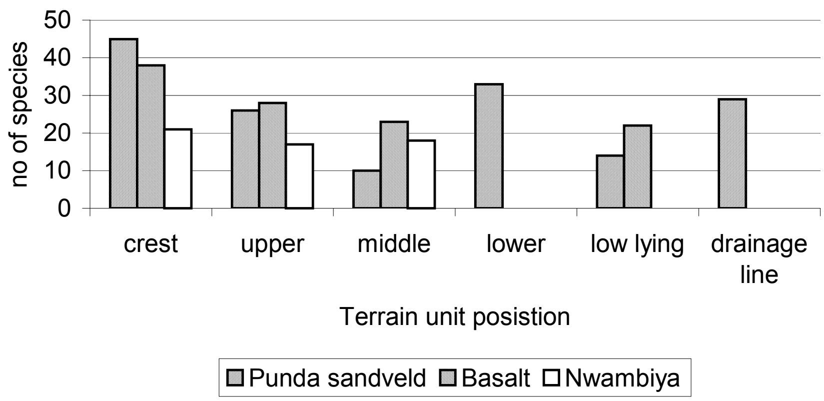


Fig. 12a. The number of tree species recorded in the specified terrain units on the northern plains. The Punda sandveld had a wider variety of species on the crests, and more terrain units were encountered there. The Nwamiya sandveld surprisingly had less species than the basalt plains in the few transects that were done.

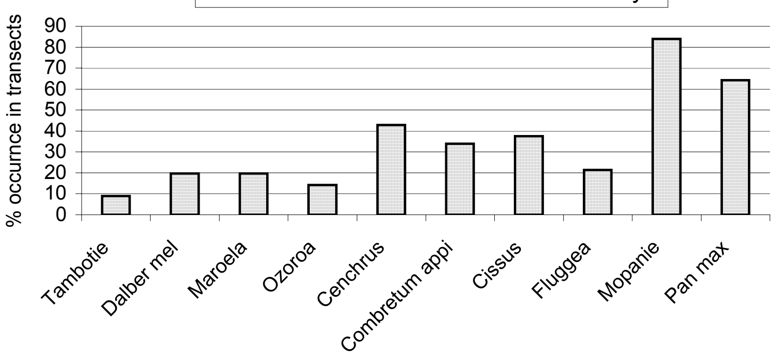


Fig. 12b. Percentage of transects where the specified vegetation species were recorded. Mopane is as expected the most commonly encountered tree species, while Panicum maximum was the most often encountered grass

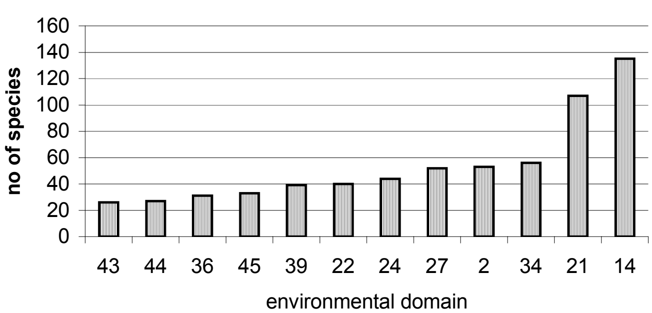


Fig. 12c. The number of tree species encountered in each environmental domain

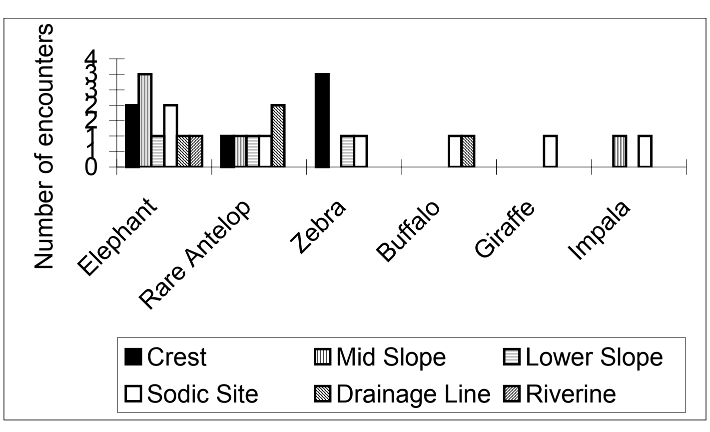


Fig 12d. Illustrates where dung heaps of animals were found, thus indicating their presence in a specific terrain unit. Elephant seem to use all terrain units while buffalo dung was only encountered along he drainage line, and impala on the midslope and sodic site.

PROGRAMME ASSOCIATED PUBLICATIONS AND THESES COMPLETED IN 2003

BENGIS,R.G., C.C.GRANT & V.DE VOS. 2003. Wildlife diseases and veterinary controls as determinants of heterogeneity in savannah ecosystems. *In:* DU TOIT,J.T., K.ROGERS & H.C.BIGGS (eds). *The Kruger Experience, ecology and management of savanna heterogeneity*. New York: Island Press.

DAVIDSON,T. 2003. Spatial and temporal responses of zebra (Equus burchelli) to changes in water distribution in the landscape. Msc thesis University of Witwatersrand.

DUNHAM,K.M., E.F.ROBERTSON & C.C.GRANT. 2003. Rainfall and the decline of a rare antelope, the tsessebe (*Damaliscus lunatus lunatus*), in Kruger National Park, South Africa. *Biological Conservation*

GRANT,C.C. & A.DE BUYS. 2003. Linking the herbaceous vegetation changes to water provision in the northern plains of the KNP. *African Journal of Range and Forage Science* 20: 149-

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CURRENT PROJECTS

Table 10. List of projects that are currently registered or that also envolve sampling in the northern plains study area.

Project title	Project leader	Co-workers	Coor-dinator	Year register	Status
The impact of tuberculosis on free-ranging lions in the Kruger National Park	D Keet:			1999	
The influence of catena soil water dynamics on the vegetation patch structure in the Northern Plains	S Lorentz		Holger Eckardt	1999	Reports
Hydro-geomorphic and vegetation characteristics of a vlei mosaic: a basis for biodiversity conservation on the northern plains of the Kruger National Park.	Prof. K Rogers	R Kruger	Holger Eckardt	2001	Complete no report yet
Nutritional ecology and habitat dependency of sable antelope in two regions of the Kruger National Park	N. Owen-Smith	S Henley	Danie Pienaar	2001	Extended
Foraging ecology of Roan Antelope (Hippotragus equinus): Key resource use in crucial periods.	N. Owen-Smith	Marie-Claire Knoop	Danie Pienaar	2001	Complete no report yet
Population viability assessment of rare antelope in the Kruger National Park. MSc.University of the Witwatersrand	N. Owen_Smith	McLoughlin, C.	Wikus van der Walt	2000	MSc & public-ation
Using Geographical Information Systems and Remote Sensing to assess the trampling and grazing impact of herbivores on vegetation in the vicinity of artificial water sources in northern Kruger National Park, South Africa		Smit, Izak P.J. ipjs2@cam.ac.uk	Dave Woods, Rina Grant	2003	Complete
Using the gradsect method to establish a prototype network of field sites for monitoring the biodiversity of the NBP.		Dr.: Margules Initials: C. R.	Andrew Deacon Rina Grant	2003	To be completed
Using hyperspectral remote sensing of plant chemicals to explain the interaction between secondary plant compounds and herbivores.	Andrew Skidmore Herbert Prins,	JG. Ferwerda,	Holger Eckardt	2002	
Hyperspectral Remote Sensing of Pasture Quality and Quantity	Andrew Skidmore Herbert Prins,	Onisimo Mutanga	Holger Eckardt	2002	
Tracking Long-term Vegetation change from Isotopic Analyses of	Prof. J. A. Lee-Thorp	J Codron	Holger Eckardt	2002	Talk at network

Project title	**Project leader**	**Co-workers**	**Coor-dinator**	**Year register**	**Status**
Elephant (Loxodonta Africana) Tusks and Hair					meeting
The influence of exclusion sites on the diversity and abundance of rodents and insectivores and associated management implications for the Kruger National Park	Prof. Mac van der Merwe	D.N. MacFadyen,	Andrew Deacon	2003	
Seasonality and 20th Century Change in the Feeding Ecology of Herbivore Communities in the Northern Basalt Plains of the Kruger National Park, South Africa	Prof. J. A. Lee-Thorp	D. Codron		2004	

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