

# **Project Reports 2006**

**Scientific Reports on Research Projects  
undertaken in the Kruger National Park  
during 2005**



**South African  
NATIONAL PARKS**



**Kruger  
NATIONAL PARK**

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**A comparison of the quality and quantity of grass along a catenal sequence in the southern Kruger National Park, South Africa**

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The objective of this study is to investigate selected ecophysiological grass characteristics including grass productivity and quality in sodic and crest patches within a granitic catenal sequence in the Skukuza land system. Grass biomass productivity data were collected over a period of three-year-growth/wet seasons.

**KNB collaboration: A comparison of community dynamics in the Northern American and South African savannas and grasslands**

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## **Vegetation monitoring in Kruger National Park using multiscale remote sensing analysis**

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The study aims to identify changes in ecosystem ‘state’ if any, as observed by changes in vegetation activity trends across a 30 year time period between 1972 and 2002. In the present study, vegetation indices generated from multispectral Landsat images (Multi Spectral Scanner (MSS), Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+)) were analysed for information on spatial and temporal heterogeneity. For each ecozone site, the following information was recorded, percentage of vegetation cover, dominant species, state of vegetation, distance from water source and management intervention if any (e.g., controlled burning, access restriction for megaherbivores). Location information was recorded using GPS. This enabled data collected from the field to be analysed in association with other cartographic data that was already in existence for the study area.

Spatial heterogeneity of vegetation shows a clear distinction between dry winter months and wet summer months in KNP. This is in agreement with the long known seasonality of the heterogeneity of vegetation in savanna environments. In general, heterogeneity is at its lowest at the end of the dry season. There are pronounced differences in spatio-temporal heterogeneity across ecozones. Ecozones having a dominant component of tree species show an increase in heterogeneity soon after rain and this increase is more pronounced if there was an occurrence of fire preceding the rain. Availability of water and the increased fertility of soil (due to ash) causes the proliferation of grass and shrub species and thereby an increase in heterogeneity.

## **Tsetse fly (*Glossina morsitans morsitans*) surveillance in the Kruger National Park**

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The main objective was to institute an early warning surveillance system to monitor re-incursion of Tsetse flies into the Limpopo/Levubu drainage system of the Kruger National Park. No Tsetse flies were caught during this survey. Numerous other flies of the genera *Haematopota*, *Tabanus*, *Musca*, *Stomoxys*, *Chrysomya* and *Sarcophagus* as well as several Tachinids were caught and collected for later identification. The mobile nets gave superior yields when compared to the fixed traps. Catches exceeding 500 flies per transect were not unusual using the mobile electric net.

Recent reports from Zimbabwe indicate that tsetse flies (probably *G. morsitans* and *G. pallidipes*) have now entered the Lundi river drainage system in the north of Gonarezhou National Park. This means that the flies will now have considerable numbers of preferred hosts to feed on, and need only to cross one more major watershed to reach the Nuanetsi river, which is a tributary of the Limpopo drainage system. With the current Transfrontier Park initiatives, the re-incursion of tsetse flies into the northern regions of the KNP has thus become a real possibility. However due to the prevailing extremely dry conditions in the northern KNP, very few haematophagous flies were caught during the survey completed in May 2005, and no flies of the genus *Glossina* were detected. In 2006, monitoring in the Pafuri area will continue and possibly extend the survey to include the Nyandu bush, using the efficient vehicle mounted electric net target trap, as well as the "Epsilon" , NGU and the new "H" odour baited traps.

**Non-lethal control of African elephant (*Loxodonta africana*) populations by means of immunocontraception**

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No work has been carried out in SANParks since 2000 and hence there is nothing to report.

## **Influence of bovine tuberculosis (*Mycobacterium bovis*) on condition and reproductive success of female African buffalo (*Syncerus caffer*) in Kruger National Park**

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The impact of the current bovine tuberculosis (BTb) epidemic in African buffalo (*Syncerus caffer*), in the central region of Kruger National Park, South Africa, was investigated in relation to reproductive success of females. Over a four-year period, 72 marked adult females of known BTb status were compared by age, reproductive status, calf survival and body condition (an indicator of health and nutrition) during the wet and dry seasons. Age did not correlate with the likelihood of infection. Similarly, reproductive status, and calf survival, were not found to be correlated with age for female buffalo. BTb positive cows had significantly smaller gain in condition during the wet season than BTb negative cows suggesting that gestation may be the critical stage of reproduction for infected animals. Barren BTb positive cows started the dry season in poorer condition suggesting that these cows could have been inhibited from reproducing by the disease.

BTb positive cows that reproduced probably suffered from subclinical symptoms, and were therefore able to maintain condition, although pregnant cows may have appeared healthier than they were due to the presence of the foetus. Calved cows ended the dry season in significantly lower condition than barren cows, but tuberculosis infection did not appear to reduce the ability of infected cows to reproduce and did not reduce calf survival. There was an indication of long-term reduction in reproductive output for infected cows, but this needs to be investigated further. A condition threshold may exist for reproductive ability, below which reproduction is inhibited. In the absence of sudden environmental change, which could otherwise breach the condition threshold, we suggest that BTb is unlikely to have a great impact on population dynamics of buffalo. African buffalo are therefore excellent maintenance hosts for this chronic disease, which may be of major concern for management and conservation of more susceptible species.

## **Assessment of woody canopy cover in savanna areas with remote sensing**

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## **The effect of rainfall variability on the survival of savanna tree seedlings**

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## **Monitoring a water hyacinth infestation on Engelhardt Dam as part of an integrated management plan for water hyacinth control in South Africa**

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The project aims to develop an integrated management plan for water hyacinth control, combining biological control, herbicidal control and nutrient control, tailored to the climatic regions of South Africa.

To date, eight months of sampling have shown Mkadhzi spruit to be a low nutrient, warm site, where the biocontrol agents are apparently maintaining control of the weed, without herbicidal intervention. The site has as recently as August 2005 been separated from Engelhardt Dam using a floating cable in order to monitor the progress of the infestation in the spruit. By preventing movement of the weed in and out of the dam we will be able to show with confidence, exactly what is happening in the agent/weed interaction in the spruit and decide if biocontrol alone is sufficient to maintain control of water hyacinth. The intention is to keep monitoring Mkadhzi spruit as described above, for at least another three years. If the site becomes overrun with the weed we may request spraying with a low dose of herbicide. However, this will not happen within the next 12 months as we wish to see how the site progresses through the coming spring and summer months.

## **Structure and function of upland riparian boundaries**

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The project goal is to determine whether the structure of riparian vegetation influences the role of the riparian zone as a modulator of flows moving between the upland savanna and the river. Animal movement and nutrient distributions across the riparian zone may be differentially affected by vegetation structure. Additional contrasts in the system such as soil parent material and location on the hydrologic network may influence the interaction among vegetation structure, animal movement, and nutrient dynamics. To investigate these links, 45 sites have been selected along the Shingwedzi and its tributaries. These sites represent 5 replicates of the following 9 treatments: 1-6) continuous, discontinuous, and sparse canopy on granite and basalt derived soils, 7-8) savanna uplands on granite and basalt soils, and 9) granite block tributaries. During the past year we have quantified the three dimensional structure of the riparian zones at these 45 sites using a combination of lidar data and data collected in the field on vegetation structure and composition. The field work was conducted in March 2005. At each of the sites we also characterized understory vegetation, the presence of animal trails, and collected soil and green plant tissue for nutrient analyses. We collected the soils and tissues to determine whether the contrasts in the system were reflected in the chemistry of these samples. Tissue samples were taken from all species that contributed to > 85% total vegetation cover of the plot. We have quantified total Carbon (C) and total Nitrogen (N) in the plant and soil samples using a CNS analyzer in the IES analytical lab. We are currently developing a protocol to extract nitrogen, carbon, phosphorus, potassium, sodium, calcium, and magnesium from the soil samples using a microwave digestion technique. We will also digest the plant samples for nutrient analyses. These analyses are ongoing and results are not yet available.

## **Collection of insects for evolutionary studies of their relationships**

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The object of our work was to recover South African representatives of the target insect orders Mantodea (praying mantises), Isoptera (termites), Odonata (dragonflies) and Coleoptera (beetles) as part of global collecting efforts to sample the diversity of these important insect groups and understand their evolutionary history. Collecting was very successful; nine species of Odonata, nine species of Mantodea and three species of Isoptera were recovered.

## **Seasonality and 20th century change in the feeding ecology of herbivore communities in the Northern Basalt Plains of the Kruger National Park, South Africa**

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This project aims to test these contrasting models in free-ranging herbivores while accounting for inter- and intra-taxonomic dietary variations. The bulk of the work is focused on the Northern Basalt Plains, with the aim of modeling dynamics of plant-herbivore interactions in a system that supports the Park's remaining roan antelope *Hippotragus equinus* and tsessebe *Damaliscus lunatus* populations. Nutritional assays (NDF, ADF, ADL) are currently in progress, and should be completed by the end of July 2005. While it is essential that these assays be compared against isotopic data, some significant results based on isotopic analyses (and %N) have been obtained.

While isotopic data do not allow for testing differences between browsers and frugivores, the results for grazers indicate that the browser/grazer continuum has a simple trifold diversity, i.e. browser, grazer, and mixed-feeder. No relationship exists between diet and body size. Moreover, diet quality does not appear to be related to body size. However, the latter analysis is based only on faecal %N, which may be influenced by phenol uptake and nitrogenous contributions to faeces of gut microbes and sloughed endogenous tissues. It is expected that NDF and ADF data will further resolve this question, as well as providing a test for whether grasses should truly be considered inferior quality foods to browse.

Mixed-feeding impala *Aepyceros melampus* diets may vary to comprise anywhere between 100 and 0% grass. They consistently eat higher proportions of grass during the wet season. A significant correlation has been found for grass intake along a west-east gradient, due in part to differences in the floristic composition of granites compared to basalts. However, these correlations reveal more complex trends than simple granite/basalt differentiation, such as increased grass intake in sodic environments. Interestingly, impala at Punda Maria maintained a higher percentage grass intake throughout the seasonal cycle compared to any other region of the Park. Inter-species comparisons of diet suggest nutritional stress in roan antelope (although still based largely on faecal %N). However, new data reveal higher %N in the Mooiplaas enclosure

than at N'waswitshumbe, and amongst free-ranging animals (but the latter are constrained by small sample sizes).\

Data analysis will require modeling the relationship between diet and nutritional content of available forage, cluster and/or principal components analysis along a continuous gradient for separation of dietary groups, and regression models for predicting the effects of feeding style, body size, and digestive anatomy. Attention will also be paid to nutritional content of forage in different microhabitats of the Northern Plains, and in comparison with other habitats (Punda Maria, Hans Merensky Nature Reserve). Further attention will be given to the implications of variation, an often neglected theme in ungulate ecology, for palaeoecology, conservation ecology, and the interface between the two disciplines.

## **The sampling method of elephant (*Loxodonta africana*) tusks**

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Isotopic data from plants, faeces, and tail hair, as well as nutritional data (%N, NDF, ADF, and ADL) for available vegetation were used to study current spatio-temporal trends in elephant diet ecology. The modern materials have already yielded exciting preliminary results and will provide the basis for interpreting isotopic data and historic diet shifts recorded in ivory. This report deals only with the results of isotopic analysis of ivory, in particular that of six individuals from the Letaba Elephant Hall.

Overall, northern individuals had slightly higher mean  $\delta^{13}\text{C}$  values than the southern ones ( $P < 0.0001$ ). However, the difference is small ( $<1\text{‰}$ ), and at this scale, variations in plant  $\delta^{13}\text{C}$  obscure diet interpretations, hence, the higher grass consumption of northern populations compared to southern counterparts, documented from faecal analysis was not apparent between the 1930's and mid 1980's (i.e. the life span of the Letaba individuals). Ivory from the Skukuza stockpiles showed higher grass intake in northern elephants during the 1990's, and the samples are  $\delta^{13}\text{C}$ -enriched compared to Letaba ivory which extends only to the 1980's. This suggests a dietary shift occurred in the last two decades.

Previous dating of samples in profile placed the shift in the early 1970s, but this was a tentative suggestion based on counts of macroscopic growth layers. Macroscopic rings are problematic, since growth layers may become compressed during calcification. Current and future research requires more rigorous dating methods to extract the maximum value from these data.

## **A study of the interactions between fire, vegetation and nitrogen dynamics in the Kruger National Park**

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Fire is a prevalent ecological process in savannas and may dramatically influence ecosystem structure, composition and nutrient cycling. Many important questions regarding the possible direct or indirect effects of fire on vegetation remains unanswered. The study considers the possible contribution of increased anthropological nitrogen deposition in ameliorating limited plant available nitrogen. The field component to this study is dependent on the growing season and data has been accumulated for two growing seasons (Summer 2003/2004 and summer 2004/2005). Data and findings will become available at the end of the present growing season (June 2005). Historical grass compositional data will be compared with a more recent grass composition to establish if any change has taken place in the dominant grass functional types. Tree biomass will be estimated for each treatment on the basis of allometric relationships between stem diameter and biomass components. Sampling of basal diameter has taken place during Feb 2005. Continued difficulties are being experienced as many small trees (< 0.5 m) have hampered the use of allometric relationships. Other methods, such as inferring tree densities from aerial photography have proved equally problematic. Leaf Area (LA) will be inferred from canopy analyser readings. LA will enable the computation of leaf biomass.

Nitrogen seems to become available to plants in KNP only during short periods of the year, usually after the commencement of the first rains. Strong competition exists between trees and grass for the limited amounts of N becoming available. In order to determine if trees and grasses have different competitive abilities in taking up available nitrogen, a tracer experiment was conducted (December 2004). A quantity of material with a  $\delta$  value significantly different from any background level is added to the system. The observation of its fate allows the study of the fluxes and/or transformations. Field application of labelled  $(\text{NH}_4)_2\text{SO}_4$  will occur in the experimental burn plot TGP enclosure at Pretoriuskop.

In the present study, nitrogen isotope analysis on adult tree study species via tree coring will establish if nitrogen deposition has been a significantly nitrogen source to plants. It has been predicted that the natural abundance of  $^{15}\text{N}$  would increase over time in plants from ecosystems that experiences high rates of N deposition from the atmosphere. High rates of N deposition lead to increases in net nitrification, which leaves behind  $^{15}\text{N}$ -enriched  $\text{NH}_4^+$  and produces  $^{15}\text{N}$ -depleted  $\text{NO}_3^-$ . As trees prefer  $\text{NH}_4^+$  to  $\text{NO}_3^-$  as an N

source, trees should become enriched in  $^{15}\text{N}$ . It has been noted, however, that a decrease in  $\delta^{15}\text{N}$  values in North America can be the result of increased deposition of isotopically light nitrate and ammonium over time.

## **Below ground processes experiments**

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The project seeks to determine the relative importance of nitrogen and phosphorus limitation in belowground processes and plant production. In each plot, we harvest aboveground biomass and separate the biomass between grasses and other herbaceous dicots. Harvests occur in January and March. In the fertilization experiment, preliminary results show a significant increase in biomass with N and P addition and even greater production with fertilization with N and P. Future years' harvests will determine the long-term, interannual relative limitation of productivity by N and P. Differences among plots in microbial populations are being determined as is the relative importance of N and P for decomposition of shoots.

## **Longitudinal studies of bovine tuberculosis in the buffalo population of the Kruger National Park**

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## **Ecology of the honey bees (*Apis mellifera scutellata*) in the Kruger National Park, South Africa**

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A total of 30 nests were sampled throughout the park on the fieldtrip in June 2005. Out of 200 hives placed throughout the park only 12 were sampled. There seemed to be a lot of movement of bee colonies as some of the boxes previously inhabited were now abandoned. This was also the case for a few natural nests. Only 2 swarms settled in previously empty boxes. Although the Cybertracker system might eventually prove more efficient than the trapping of swarms in boxes, it would be recommended that the boxes be kept in the park so that when a need arises to check the health of the colonies, this can be done by opening the boxes since it is impossible for natural nests in trees or rocks.

Twelve bee colonies were found to be infected by the *Varroa* mite. A proportion of 12 infected colonies out of 30 nests checked was very high compared to the previous sampling in October 2004 (2/32). This could be explained by seasonal effect, the mites usually hitchhike on the drones, but if no drones are present but brood is still produced, the mites still breed. They might then use workers as transport instead of drones. This could be why they were found so often on the foragers collected this winter. Only one of the boxes was infected (in the rhino cemetery), all the other infected colonies sampled nested in trees. Samples collected have been processed once finished, the data will be analysed. A visit of Dr. Per in November should boost this process as he is more knowledgeable about the analyses needed.

## **Survey of Arachnida of the Kruger National Park with emphasis on spiders (excluding mites and ticks)**

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As part of the South African National Survey of Arachnida (SANSA) an inventory of the Arachnida of the Kruger National Park is underway. The arachnids (spiders, scorpions, solifugids, amblypygids and pseudoscorpions) constitute an abundant and highly successful group of invertebrate animals. In the past invertebrates were largely ignored in conservation endeavours and meaningful conservation cannot take place if species involved are not known. Therefore, surveys of the arachnid fauna in reserved areas, where conservation strategies are already in place are becoming very important. The overall aim of this project is to collect, describe and make an inventory of the Arachnida species of the Kruger National Park.

The survey is on going and progress consists mainly of material from previous collecting trips that have been identified. During a collecting trip last year to the Letaba Camp (M. Paulsen and I. Engelbrecht) several baboon spider species were collected. One of them was identified as a new species namely *Ceratogyrus paulseni*. Three females of this species were collected and deposited in the National Collection of Arachnida in Pretoria. During a second trip by M. Cumming in May 2005 to the park, 16 spider families were collected represented by 29 genera and 31 species. Ten species were new records for the park.

## **Why do giraffes occur in aggregated dispersion patterns?**

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The purpose of this study is to investigate the first of these two possibilities and to contribute to the elucidation of the second. It arises from and will extend the work of Cameron and du Toit (2005).

The lack of change in the frequency distribution of aggregation sizes between wet and dry seasons does not support the null hypothesis that giraffe dispersion patterns are primarily determined by the distribution of their food resource (though dry-season effects may be mitigated, at least in Kruger National Park, by the availability of deep-rooted, evergreen and riparian browse). By contrast, the decrease in nearest-neighbour distances with increasing aggregation size tends to support it. It is hoped that an improved understanding of giraffe social biology will be of assistance in future management initiatives and that dermatological observations, made at the request of Kruger National Park Veterinary Wildlife Services (see attached file: J B Doherty Report B) will contribute usefully to the monitoring of wild animal health.

## ***Breonadia salicina* response to the 2000 catastrophic flood, Sabie River, Kruger National Park: Implications for rule based modelling and monitoring**

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The aims of this project are, to determine the predictive capabilities of the *Breonadia* model by directly testing the model, to determine the population structure of *Breonadia salicina* after the 2000 Sabie River flood event, and to determine how the *B. salicina* population has responded to the 2000 flood in terms of utilising different response strategies in different channel types. Fieldwork has been completed (Sept/Oct 2004 and May 2005) and the results have been analysed and statistical work has mostly been completed. The major findings are:

- Recruitment of *B. salicina* occurred in some channel types and some geomorphic units demonstrating a patchiness in response at these scales. Recruitment only occurred on bedrock substrate at the substrate-type scale. Recruitment is not occurring in the Pool-rapid monitoring sites as predicted by the *Breonadia* Model but rather in the Bedrock- and most strongly in the Mixed Anastomosing channel types. Recruitment in the Anastomosing channel types is also occurring at much lower frequencies than was expected from the model predictions. There is no return to a negative J-curve size-class frequency in the Pool-rapid channel type as predicted by the *Breonadia* Model.
- Sprouting is a far more important disturbance response in *B. salicina* than was realised. Most residual trees show a strong sprouting response, especially within the smaller size classes and the more severely damaged individuals. Sprouting occurred at all scales in the river and in all channel types in relation to the type of flood damage. Flowering response occurs most strongly in larger trees that received little flood damage. Flowering could be influenced by sprouting in individual trees. Thus recruitment occurs in response to the underlying physical template while sprouting and flowering is related to individual size-class and damage severity. The complex interplay of biotic responses and the multi-scaled physical template suggests that the longer term recovery of the *B. salicina* population in the Sabie River will not be spatially uniform.
- Some of the *Breonadia* Model functions need to be readdressed. Monitoring sites need to be moved to the Mixed Anastomosing sections of the river in order to track the recruitment response of *B. salicina*. The TPC for *Breonadia salicina* size-class structure was exceeded by a natural event. High flow events that alter the *B. salicina* population structure need to be added as allowable events for exceeding this TPC.

## **Water use in relation to biomass of indigenous tree species in woodland, forest and plantation conditions**

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There is a widespread belief that indigenous trees use less water than exotic trees. However, there is insufficient information on indigenous species to prove or disprove this hypothesis. The overall aim of the project is to investigate whole-year rates of growth, and water use characteristics of indigenous tree production systems across a wide rainfall gradient, with economic comparisons against exotic plantation systems. Individual species selected for water use measurements using the HPV technique include *Combretum apiculatum*, *Sclerocarya birrea* and *Lannea schweinfurthii* trees.

HPV results so far suggest that water use by these trees is extremely seasonal and closely correlated to tree leaf area, and vapour pressure deficits of the air. Transpiration ceases during the dry winter months when the *Sclerocarya birrea* and *Lannea schweinfurthii* trees lose their leaves. The *Combretum apiculatum* trees show a similar trend in transpiration rates, however the transition between dry and wet seasons is less pronounced as these trees typically retain a proportion of their leaves throughout the winter months.

## **Vertical aerial photography as an aid for ecological monitoring in the Kruger National Park**

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Vertical aerial photography is a useful tool for ecological monitoring and is especially applied in the vegetation monitoring field. The existing aerial photographic data set is of such a scale that it can be used for detecting changes in vegetation structure, *i.e.* cover and density. In some cases it is even possible to distinguish between different woody species, especially where these are large specimens. The photographic data set covers a relatively long period, enabling one to compare historic with more recently taken photographs. Changes in vegetation cover particularly, but also to a limited extent in species composition, are easily detectable and could provide important management feedback. Since the aerial photographs are in digital format, image processing can be conducted to analyze the data. Heterogeneity indices can also be derived from the images.

The aerial photographs taken of a selected number of transects during August 2002 were analyzed and compared to the historical (winter) photographs (derived from Dept Surveys and Mapping). The next step was to relate the field survey data obtained from the experimental burn plots in 1957 to the 1940 aerial photographic data.

## **Fixed-point photography as an aid for long-term vegetation monitoring in the Kruger National Park**

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Fixed-point photography is a useful method of recording long-term changes in the vegetation. It shows gross vegetation changes in an objective visual way. Quantitative data are not easily extractable from the images because of the absence of a fixed surface area, which is ascribed to the horizontal view into space contrary to vertical views focusing on ground surface. There are, however, semi-subjective means that can be used to derive quantifiable information. One of the easier parameters is the number of individual trees, which can be simply counted in order to obtain time series data.

An additional 60 sites were selected and photographed in the Stolznek area and on the Lebombo mountains due to complete undersampling in the past. New sets of fixed-point photographic sites were compiled for the Nkuhlu, Letaba and Makhohlola exclosures, as well as for the Capricorn, Hlangwini and Buffalo breeding enclosures.

In March 2005, the triennial taking of fixed-point photographs commenced. This will be reported on in more detail in the next progress report.

After more than 900 photographs were analyzed, derived from sites all-over the KNP, some interesting results were obtained. Current findings revealed that the lower (<2m) and intermediate (2-5m) height classes are highly dynamic, changing within a period of a few years depending on fire and rainfall. Bush encroachment has been observed during more recent years; especially on the granites increase in densities of woody individuals became a scenario.

Trends in tall tree (>5m) numbers are negative, showing a sharp decline by over 40% throughout the KNP. It appears that no significant differences occur in the number of tall trees between the granites and basalts.

## **Regeneration of riparian vegetation on the Sabie River in the Kruger National Park**

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Two modelling projects have evolved under the above-mentioned title, namely:

1. Rule based modelling for management of riparian systems, and
2. Modelling of terrestrialisation and technology transfer to enable management of Kruger National Park rivers.

These two projects were developed by the Centre for Water in the Environment (CWE, Wits University) with the main objective of engaging research, prediction, technology transfer and monitoring through rule-based modelling, to enable effective management of riparian system response to changes in flow regime. In order to achieve this overall aim, various objectives were pursued.

The development and testing phase of the project has been completed and will in future be managed by the above-mentioned scientist. For more information about this project, the two reports WRC Report No 813/1/99 and WRC Report No. 1063/1/03 can be consulted.

A student, Ms Lisa Dowson, has been appointed to address some of the underlying assumptions of the Breonadia model, and also to evaluate whether the flood has changed any of the key parameters on which the model is based. She has conducted vegetation surveys at the relevant sites and will be using the data for the above-mentioned purposes.

## **Geomorphological dynamics of the major rivers of the Kruger National Park**

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This monitoring programme resulted from the concern of alluviation of rivers which is one of two major threats to the rivers of the KNP, the other being deterioration of water quality. Since the focus was falling on the Sabie River and therefore most of the work conducted on it, TPC's and models were developed based specifically on conditions prevailing along this river. The geomorphology of the Sabie and Letaba River were described in detail, resulting in a hierarchical classification system. Within a river, so-called macro-reaches were identified which were further subdivided into reaches, channel types and morphological units. The latter units form the finest scale at which the geomorphology of the rivers is monitored. While this detailed classification system is lacking for the Luvuvhu, Olifants and Crocodile River, a different system of characterization in terms of reaches will suffice in the meantime.

While this monitoring programme focuses on geomorphological changes *per se*, it must be considered in association with the riparian vegetation monitoring programme which measures geomorphological change in an indirect way.

All geomorphological work so far has been conducted by Wits University's Centre for Water in the Environment (CWE) and is on-going, constantly seeking new improved ways of monitoring.

## **Riparian vegetation Index(RVI) as part of River Health Programme (RHP)**

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The Riparian Vegetation Index (RVI) as part of the River Health Programme (RHP) is a national monitoring programme applied by various provincial conservation bodies to monitor the state of specific rivers throughout the country. This programme was implemented three years ago, however, the collected data have not been captured on computer yet for administrative reasons. Also, since the overall technique is due for major revision, no further feedback on the current status and progress of this monitoring programme can be provided here.

All five major rivers were surveyed according to this technique staggered over the last three years, *i.e.* two rivers each in one year and one river in another year.

## Mechanisms of grass/tree interactions in savannas

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The primary objective of the TGP is to develop a predictive understanding of tree/grass interactions in savanna ecosystems. It has been found that *Terminalia sericea* rooted as expected, with the smaller individuals sourcing shallower water than the larger trees. *Acacia nigrescens* did not show the same patterns. At both sites, the “grass-removal” experiment has resulted in a higher growth rate of the trees. However, at Pretoriuskop, this is not reflected by an increase in soil moisture suggesting there is competition between trees and grass but it is perhaps for something other than moisture. At Satara the “grass-removal” experiments show an increase in soil-moisture at the deeper depths suggesting water is limiting at the semi-arid site. At both sites, there is less grass under the roves than on the irrigated plots, and less grass on the “tree” versus the “no-tree” plots.

The data from the main experiment (above) will give us the relationship between tree growth and soil water regime. By installing similar soil probes on the EBP's it would be possible to determine how fire treatments have altered soil moisture, and so predict what effect this would have had on the Tree:grass. This has not been implemented as yet, but will be an integral part of the study. Changes in woody plant populations could be as a result of a varied return interval of seedling establishment events. Once successful recruitment into seedlings has occurred, the saplings get trapped in a browsing or fire zone.

**Using hyperspectral remote sensing of plant chemicals to explain the interaction between secondary plant compounds and herbivores**

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## **Patterns and processes of invasion in an African savanna ecosystem, with emphasis on multiple spatio-temporal scales**

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Many factors influence the spread dynamics and distribution of invasive alien organisms. Despite progress in unravelling the determinants of invasiveness and invasibility, robust, spatially-explicit predictive models for explaining real-world invasion dynamics remain illusive. Reconstructing invasion episodes is a useful way of determining the roles of different factors in mediating spread and proliferation. In many cases, however, human-aided dispersal and other anthropogenic factors blur the roles of natural controlling factors. We describe the reconstruction of an isolated invasion event from a known source: the 50-year invasion history of *Opuntia stricta* in the Kruger National Park. Our aim was to explore the relative roles of environment and propagule supply in shaping the invasion pattern. Environmental variables (landscape heterogeneity and distance from water sources) were moderately useful for explaining the presence/absence of *O. stricta* in 1-ha cells across the 660 km<sup>2</sup> (53% of cells correctly classified). Adding fire frequency increased the accuracy of the model (68%). However, when we considered the role of propagule pressure (measured as the distance of sites from the known primary invasion focus and putative secondary invasion foci), model accuracy was greatly improved (77%). No environmental variables or propagule pressure correctly explained spatial variation in abundance (expressed as cladode density in 1-ha cells). We discuss implications of the importance of propagule supply for modelling and managing invasions.

## **An investigation of the status of *Chiloglanus engiops* (Crass, 1960) in the Letaba River after the 2000 floods**

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A total of three surveys were conducted at four different localities, of which one is situated outside the borders of the KNP. The initial findings from data obtained during the field surveys showed that there were no *Chiloglanus engiops* present in the Letaba River system at the specific localities during the specific times of the surveys. The localities were well chosen and the habitat would favour the presence this species. The reason for the absence of *Chiloglanus engiops* in their preferred habitat is still unknown, although it would seem the lack of constant water supply to the system might be the greatest factor determining their absence in the system in this point of time.

## The Spatial and Temporal Scale of Vegetation Change in Kruger National Park

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Savanna ecosystems are highly dynamic, their vegetation structure can change dramatically due to the influence of fire or changing herbivore populations. This presents dilemmas for habitat managers, who must decide on appropriate management strategies for National Parks and other savanna areas. Often, long-term data on vegetation change is lacking, and managers must interpret current habitat change without the benefit of knowledge about the natural variability and resilience of ecosystems. Palaeoecology has the potential to supply such data, providing a spatial, temporal and quantitative context for the interpretation of ecological change taking place today.

The relationship between vegetation structure and charcoal abundance at Mafayeni is clearly time-transgressive. In the oldest part of the core (from approximately 1370 BP), charcoal abundance is low, but there is a sudden transition at after 86cm depth, beyond which charcoal abundance increases. There is a continued trend of increased charcoal abundance to the present day. At the same point as the transition in charcoal abundance, the abundance of Poaceae pollen falls while the abundance of Cyperaceae pollen appears to become more variable. The abundance of pollen from trees and shrubs remains approximately constant throughout. At Makwadzi, there is a general decreasing trend in charcoal abundance over time from 1560BP, a trend which is interrupted by two peaks in charcoal density. A peak in Cyperaceae pollen is coincident with the second peak in charcoal abundance, and following this there is a trend of increasing pollen from trees and shrubs and decreasing pollen from Poaceae. Pollen preservation at this site was poor, which raises some issues of differential preservation which require further investigation. At Malahlapanga, very little charcoal is present in the oldest section of the core (from 4940BP). In this section of the core, the abundance of pollen from woody plants and from Cyperaceae is low, and the abundance of Poaceae pollen is high. At 56cm depth, however, there is a dramatic transition, after which charcoal abundance and Cyperaceae pollen increases, while Poaceae pollen decreases. There is also a slight increase in the abundance of pollen from trees and shrubs following the transition. The pollen data from Mapimbi are extremely dynamic, indicating highly variable vegetation over the past 700 years. The abundance of Poaceae pollen, and pollen from trees and shrubs varies dramatically over time, suggesting several transitions between more and less wooded vegetation over time. Throughout, the Cyperaceae abundance is low, and charcoal abundance is generally low but variable.

## **Veld burning in the Kruger National Park**

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The role of fires in the history and shaping of the landscape of the Kruger National Park (KNP) can be traced as far back as 1912. Trollope, 1998 and Biggs, *et. al.*, 2003 summarizes the history of the experiment, highlight the future of the experiment and point to further references. Very briefly, by the 1950's it had become clear that knowledge pertaining to where, when and how often the veld (rangeland) in the KNP should be burnt was severely lacking. In 1954 a fire research programme was initiated in the KNP in the form of the experimental burn plots (EBP's) (Brynard 1971). The initial objective of this project was to investigate the effect season and frequency of burning has on vegetation in the four major vegetation communities in the park (Van der Schijff 1958).

## **The present status and future sustainability of the pollination system of *Ficus sycomorus* in the Kruger National Park**

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There are several factors that may threaten the long-term sustainability of this fig-fig wasp obligate mutualism. First, competition between the pollinating wasp species and other wasp species that seem to utilize the same niche could result in the systematic loss of the pollinator. Second, since wasps only live in the fig fruits, irregular and clumped fruiting patterns can lead to periods where there may be no habitat for the wasps. This may become a crucial problem if phenology is closely linked to precipitation, which is expected to change in the future.

Apart from quantifying the phenology, we are testing four possible explanations for a stable coexistence between competing species. 1) Niches are different, 2) Competition is prevented by temporal division of habitat, 3) Facultative sex ratio adjustment by wasps may be a density dependent population growth regulator, and 4) the wasp population may consist of a metapopulation that will allow a 'chaotic' coexistence.

One species actively compete with the other species. This is a very exciting finding and we hope to publish this soon. This finding could explain the species' persistence despite its weaker competitive abilities otherwise. We have been able to collect samples regularly at two-month intervals. Data will only be analysed once several years worth have been collected.

## **Population dynamics and elephant movements within the Associated Private Nature Reserves adjoining the Kruger National Park**

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A total of 212 sightings of family units were made during this study. The identikits of 11 new bulls were collected from June to August 2005. Of the 497 sightings of bulls during the period under review (which included multiple sightings of the same individual within a particular month), 91 of these were already on record. As 91 of the 171 different bulls sighted during the period of this report were re-sighted individuals, we are presently on a 53% re-sighting rate. Eight collars are currently deployed; five on bulls and three on cows. Three study animals have been monitored for more than a year (Mac, Classic Charlie and Diney). A new study sight on the vegetation impact study has been established on Ntsiri with the co-operation and assistance of the manager, Carl van den Berg. Both the Vlakgezicht and Ntsiri study sites will be incorporated into a long-term monitoring programme. The monitored trees will be revisited on an annual basis to determine the efficiency of the wire netting. Three natural mortalities have been reported during the period under review (August 2004 – Aug 2005).

## **Geomorphologic modelling of the interaction between river flow, sediment and vegetation**

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This study employs a modelling approach that is based on the tendency of natural systems to self-organise in scale hierarchies. Separate models for describing vegetation and sediment dynamics at their appropriate scales are integrated such that their interactions are described through feedback between the models. Prediction both river geomorphology and vegetation patterns allows working with the river rather than against it. This means that a greater understanding of river behaviour can be utilized in devising management strategies that are as consistent as possible with natural river activity. Modelling can assist the KNP management to ensure that their objectives and visions are realised. These visions and objectives serve upper management levels with statements of strategic purpose, while low-level goals provide on-the-ground managers with specific, spatially and temporally bounded end points, which are known as Thresholds of Potential Concern (TPCs). A model has been developed that addresses particular scientific and management problems through making predictions and carry out analyses, at appropriate spatial and temporal scales. The model predicts the effects of changes of both the river channel form and vegetation when impacted on by flow regime. The model could be fundamental to solving management problems as it would enable better prediction of the ecological effects of changes in river flow regimes.

## **Nutrient stoichiometry of plants and soils in the Kruger National Park: Implications for savanna structure and function**

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This project investigates stoichiometric relationships between multiple nutrients in different ecosystem components across large-scale gradients of rainfall and nutrient availability in the Kruger National Park. Plant and soil samples were collected from 108 different sites across the Kruger National Park in both dry and wet seasons, with the objectives of analyzing total C, N, P and trace nutrients in samples. Preliminary results indicate that during the dry season, plant nutrient stoichiometry does not reflect the stoichiometry of total available nutrients in soils. Plant C/N and N/P ratios are highly variable and near zero slopes on regression lines suggest some degree of homeostasis in plants.

No consistent patterns in plant and soil nutrient stoichiometry were evident across large scales (e.g. basalts vs. granites, north versus south), although soil C/P and N/P ratios differed between granites and basalts during the dry season. Soil nutrient heterogeneity was more pronounced at smaller “patch” scales (sodic versus non-sodic sites; across soil catenal positions) than at larger landscape scales. In plants, associates of small scale variation remain unclear, although sodic sites are a key source of variation in plant tissue nutrients. Different plant growth forms (fine leaved trees, broad leaved trees and grasses) differed in their C/N and N/P ratios. Dry season Acacia leaves have low C/N (and high N/P) ratios that are highly invariant across the landscape. Acacia leaves thus represent a highly predictable source of forage nutrients for herbivores in the dry season. Similarly, sodic sites also represent a key forage refuge for herbivores in the dry season, supporting plant tissue with higher concentrations of key micro-nutrients than other sites.

The spatial patterns in wet season plant and soil stoichiometry were qualitatively similar to those found for the dry season. Once again, plant stoichiometry (we report on plant N/P ratios here) was unrelated to environmental variables such as rainfall or soil geology (granite or basalt), or to soil nutrient status (soil N, soil P). Most variation in wet season plant stoichiometry occurred in the context of plant functional groups

## **Biocomplexity in African Savannas: Ecological self-thinning in the Kruger National Park as a measure of tree on tree competition**

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The overall objective of our project was to provide a better understanding of woody community dynamics in savanna systems, including interactions with herbivores and fire. We sampled and analyzed new and existing data across a sub-sample of the Ecological Burn Plots (EBP's) in the KNP. Specifically, we examined the role of tree on tree competition in structuring savanna plant communities through use of the ecological self-thinning concept. Although fire has been continually suppressed at the four Mopane EBPs since the inception of the program in 1954, a large fire at the N'Shawo control plot in 2001 dramatically affected the woody biomass in the plot. In fact, we compared the control N'Shawo with existing three-year burn plots. Results suggest that the control plot with one large burn event in 2001 had a greater reduction in total woody basal area than did the three-year burn plots, although there were substantially more burns in the three-year plots since the beginning of the EBP program in 1954.

The fire-exclusion plots have woody plant values that generally are near the self-thinning line. Surprisingly, a large number of the three-year February (wet season) burns plots have values that nearly approach the self-thinning line, which may be indicative of trees surviving to a sufficiently large size to be protected from fire damage. Many of the points for dry season burns (one and three-year burns) are considerably depressed from the self-thinning line, particularly for the smaller size classes for trees. The results of this study suggest that woody vegetation dynamics can be better understood using a relatively simple concept from ecology: the self-thinning concept. Through use of self-thinning we not only can better understand how woody plants interact, we can also begin to postulate testable hypotheses about tree-grass interactions. For example, if a robust self-thinning line is found to apply across a range of tree sizes for a savanna, then this suggests that tree-grass interactions may be invariant to tree-size, with exception of trees at the seedling stage. Fire and browsing generally led to lower points on the self-thinning plots. The results of this work, however, clearly show that the effects of fire on savanna vegetation depend crucially on the frequency and season of burn. Single burns with very high fuel loads in the control plots (N'Shawo, Miyabiti, and Napi) had larger reductions in woody basal area than regular cool season burns at greater frequency.

## Biocomplexity in African Savannas

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We are developing both conceptual and numerical models that will help us explain and analyze savanna dynamics, and new theory to explain how biogeochemistry, climate and disturbance interact and contribute to savanna dynamics across scales of space and time. The project uses savanna systems as a general model for understanding complexity in biological systems and to develop methods of analysis and interpretive tools that promote a broader public understanding of the inter-relatedness of environmental systems.

A major theme in savanna research centers on the mechanisms that permit the coexistence of two distinct life-forms: trees and grasses in savannas. Theories for the coexistence of trees and grasses in savanna systems have been divided. The lack of consensus on determinants of savanna structure and function arises because different models: i) focus on different demographic stages of trees, ii) focus on different limiting factors of tree establishment, and iii) emphasize different subsets of the potential interactions between trees and grasses. We believe an integration of competition-based and demographic approaches is required if a comprehensive model that explains both coexistence and the relative productivity of the tree and grass components across the diverse savannas of the world is to emerge. The results further suggest that savannas switch from being water-limited systems to disturbance-mediated systems across a gradient of increasing rainfall. Between 150-600mm MAP, water availability tree cover and permits grasses to persist in the system. In this range of rainfall, fire grazing, although capable of modifying tree-grass ratios, are not necessary for tree-grass coexistence. Above 600mm rainfall, water availability appears sufficient to support tree canopy closure such that grasses can be outcompeted. These results have been a for publication in *Nature* and will appear shortly.

## **SynBioSys Kruger - An information system for the evaluation and supporting the management of biodiversity among plant species, vegetation types and landscapes in the Kruger National Park**

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In 2005 two visits to Kruger Park have been paid by the research team. The first visit by George Bredenkamp, Theo Mostert, John Janssen, Loek Kuiters and Joop Schaminee was from 4-12 of April, the second from 15-19 of August. The first visit was mainly focusing on the vegetation of Kruger Park. By compiling all available vegetation plot records into a classification system field studies were carried out to validate and to refine the provisional classification. Also a few hundred photographs have been taken to illustrate the various vegetation types. The classification as well as all available plot records will be incorporated in the information system and link to other levels of information (e.g. plant and animal species, landscape and soil types). A few pictures during the first visit are included at the bottom in this report. The second visit by Stephan Hennekens, Peter Verweij and Theo Mostert was mainly focusing on data inventory and to set up a framework for the information system. Some staff members of the ecological staff of Kruger Park have been interviewed for getting an overall picture of the data available and the needs of the staff members. A Powerpoint presentation has been compiled to demonstrate how the information may look like. This presentation was discussed with Holger Eckhardt. The development of the prototype application is currently in progress; the expected date of delivery is 16 December.

## **The ecological determinants of group size and composition in terrestrial primates**

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The primary objective of the research project, therefore, is to survey the size, composition and density of baboon and vervet groups throughout the Kruger National Park. The observed variation in group size and composition will be assessed alongside factors such as climate, vegetation structure, geology, surface water availability, predator and herbivore densities and tourist/restcamp locations to determine the key variables underlying sociality in primates. These findings will be fed back into our systems models of primate socioecology to develop a highly robust model of the ecological constraints on terrestrial primate sociality. To date, two trips to KNP have been made since the beginning of the project. Both surveys have indicated that the highest primate densities are in the area of the Sabie and Sands rivers between Skukuza and Lower Sabie and also along the Luvuvhu River around Pafuri.

## **Biological control of *Opuntia stricta***

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Two herbivorous insects, a phycitid moth, *Cactoblastis cactorum*, and a cochineal insect, *Dactylopius opuntiae*, have been introduced into KNP for biological control of one of the park's most troublesome invasive species, *Opuntia stricta*. Both insect species are well established in the park and, particularly the cochineal, are causing widespread damage and mortality of the weed. The density of *O. stricta* has declined by over 85% in some areas and continues to decline. Fruit production and long-range dispersal of the weed has been severely impeded by the insects. This project ranks among the most successful of the many biocontrol programmes that have been undertaken in South Africa during the past 90 years and is realizing massive savings for KNP. A long term monitoring programme is continuing to quantify the eventual levels of control that are achieved and to determine how sustainable these are.

**The spatial demography of selected tree species in the Kruger National Park, in relation to elephant impacts**

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## **Ennobling the indigenous African Marula (*Sclerocarya birrea* subsp. *caffra*)**

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‘Foods from the Veld’ by Fox & Young (1982) clearly states that more than a thousand wild plants are known to be eaten in Southern Africa. However, not a single one is commercially available in the horticultural world. Since 1980 the University of Pretoria, Kruger National Park and the Tshwane University of Technology embarked on a project to ennoble the indigenous Southern African fruit trees. The first outstanding candidate was the Marula, well known to the indigenous people for its outstanding fruit production and quality.

Several thousands of wild variants were visited of which ±20 were selected, fruit production and quality were yearly confirmed. Four of these superior ennobled cultivars were found in the KNP and in 2004 application was made to the Department Agriculture division of Genetic Resources to be registered and provisional protection under the Plant Breeders law was given.

To obtain the final certificate, Genetic Resources require that an orchard of daughter trees (clonally propagated) must be established to prove the genetic stability of the new cultivars. Replicates of the new cultivars will in 2006 be planted at Skukuza, Phalaborwa, Nelspruit and Pretoria. The trees have been grafted and tree planting ceremonies at the sites will be organised by the public relations division of the different institutions involved. Thus it can be concluded that the Africa Marula has been ennobled and released to the International Horticultural world with outstanding economic potential for fruit juice, jelly, liquor, oil, preservative, nuts, etc.

## **Elephants and mopane caterpillars: interactions through a shared resource**

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## **Global soil macrofauna diversity and ecosystem function: Baseline data from South Africa**

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We were collecting termites for DNA sequencing, to include them in a worldwide study of termite relationships. This larger project is what I have been spending my time on, and I now have a very good (and large!) termite phylogeny, which I am presently preparing for publication. The termite species that we collected at Kruger were checked through for species of importance for DNA sequencing, but are otherwise waiting their turn to be identified and included in the global-level comparison of termite assemblages, which will ultimately be published when we have some of the more pressing work completed. My comments on the higher termite species richness around Punda Maria is therefore mostly observational at the moment - I remember that this was the only area in the park where we found one of the species of the 'Cubitermes group', a clade of species which are most diverse in tropical rainforests, and which are not found in arid environments. (Bear in mind that the great majority of termites exhibit similar diversity patterns).

The data from the soil transect that we conducted near Pafuri is also part of a global-level study, and one that is gradually being added to, so this will be a little while yet before it will be fully analysed and written up for publication. I have spoken with Dr Paul Eggleton, who will be taking the lead in the analysis of this data, and he tells me that although he cannot say much specifically at the moment, the order level data from the leaf litter and soil scrapes at Pafuri fits the general model of being a typical sub-tropical assemblage on a large continental land-mass. Also as expected for a dry forest sample, as Pafuri was, the proportion of ants and termites there is less than would be expected from an equatorial moist forest site. As I mentioned, termite diversity declines as the habitat becomes drier. There is also a tendency towards fewer soil-feeding species and increased diversity of the fungus-gardening species (the Macrotermitinae that we found in the many large mounds). By living in mounds, they are able to regulate their conditions in a manner optimal for the colony, despite being in relatively dry conditions. This is clearly harder for species living more freely in the soil (which prefer moist forest conditions), hence the loss of species such as the Cubitermes in the drier areas of the park.

**Habitat preferences, home range size, distribution and general biology of the critically endangered Juliana's golden mole (*Neamblysomus julianae*) in Kruger National Park**

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Despite its current conservation status, the critically endangered Juliana's golden mole has received almost no research attention to date. Our research project aims to gain an insight into the general biology, habitat preferences, distribution and home range size of these small, fossorial insectivores. Golden moles are very dependent on soil conditions and as such are extremely range restricted. Our work to date primarily focused on mapping their distribution within the Park and detailing ecological variables associated with their distribution.

Golden moles feed at night making superficial foraging tunnels just below the surface of the soil. A characteristic trail remains and reveals the presence of golden mole activity in a given area. We successfully located several tunnel systems, most of which were in the Pretoriuskop Landtype with very few in the Malelane Landtype. Surveying potentially suitable terrain in the Malelane area is much more difficult due to the highly undulating landscape that is often covered in a tall, thick grass layer that hides mole tunnels. Trails located in this region were found to be slightly deeper than in the Pretoriuskop Landscape and general habitat characteristics vary markedly between these two landtypes with seemingly few shared properties.

## **Biogeochemistry, herbivory and plant productivity in riparian ecotones and associated savanna upland ecosystems**

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The central objective of this study is to clarify biogeochemical dynamics within riparian ecotones and the associated upland ecosystems in the semiarid Lowveld savanna in South Africa. In the first year of the study (2004), we found that the nitrogen mineralization and plant herbaceous biomass was highest in the wettest landscape positions. Biomass was especially high in the enclosure where large herbivores have been absent for two years. In the favorable hydrological and biogeochemical conditions grasses were able to increase their standing biomass, however, this increase came at the loss of forb species richness in the riparian and riparian-sodic boundary areas.

In the second year of the study (2005), these trends continued. In addition, stocks of nitrate and ammonium was also high in these landscape positions, however, elevated nitrate concentrations was also evident from the sodic area. These results show that water is the primary limitation to nitrogen cycling in semiarid savannas, similar to what was found in Nylsvley a semiarid savanna in northern South Africa. It is also consistent with trends in mesic riparian zones where nitrogen cycling was elevated in riparian zones compared to the uplands. In the enclosure, a 200% increase in biomass was recorded in 2005, significantly higher than in the reference area. Significant increases were also evident in the sodic area and the sodic-upland boundary.

## **The 4<sup>th</sup> Wild Dog & 2<sup>nd</sup> Cheetah Photographic Survey in the Greater Kruger Region**

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Photographic surveys using material submitted by visitors to Kruger of wild dog and cheetah have proved to be a useful way of monitoring population trends in these species. Previous surveys and the analysis of the data have suggested that a shorter time frame than 18 months might yield comparable results. Accordingly this survey was conducted over a seven month period. A total of 414 entries (163 of cheetah and 251 of wild dog) comprising over 4000 photographs were received.

Statistical analyses using the rarefaction technique suggested that wild dogs had been adequately sampled, in the southern district, but less well so in the central and northern districts. This was supported by rangers' observations. However, cheetah were poorly sampled throughout the KNP. Alternative analyses using mark-recapture statistical techniques are presently being conducted which may offer a more suitable calculation of the number of wild dog packs and total number of cheetah.

Preliminary results indicate that the wild dog population is a minimum of 140 in 17 packs, which suggests a decline from the 2000 survey when a minimum of 177 in 25 packs was counted. However average pack size has increased slightly from 7.1 in 2000 to 8.2. Clearly wild dogs numbers have not recovered in Kruger from the peak of 434 in 36 packs counted in the 1995 survey. The continuing years of above average rainfall is believed to be the major reason for the low numbers and it is believed that several dry years are needed to reverse the population trend. A total of 103 cheetah were identified compared to 172 in the previous survey in 1990/1991. This is believed to be due to the shorter time frame in the latest census (7 months compared to 14 months). Before further conclusions are drawn the data will be analysed using capture-recapture models, but the indications are that the population has not changed significantly since the previous survey.

## **The epidemiology of tuberculosis in free-ranging lions in the Kruger National Park**

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## **Soil development as a function of topographic attributes and location along geo-climate gradients in a semi-arid savanna landscape**

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Arjun Heimseth from Dartmouth University visited us in June to lend expertise assistance on constraining the rates of chemical weathering that we are measuring. He uses cosmogenic nuclides to estimate the rates of soil production and erosion on hillslopes and rates of river incision in stream channels. We collected saprolite samples in a nested strategy throughout our study area between Skukuza and Shingwedzi. These samples are co-located with the soil pits in which we are currently measuring chemical weathering. The physical weathering rates from the cosmogenic data are an unprecedented opportunity for us to acquire the downwearing rates of the landscape over millions of years. When we couple the physical and chemical analyses, we will be able to provide a quantitative appraisal of how much and how fast the Kruger is losing matter. Arjun Heimseth is using these data as part of global effort to measure erosion and soil production rates. His other field sites are in Australia, Nepal, North-eastern United States and other parts of the world.

Andy Kurtz from Boston University visited us in April to study weathering and landscape development on the western side of the park, which is underlain by 3.0 Ga granitic gneisses of the Kaapvaal craton. We are in a joint effort to contrast downslope major and trace element mobility for granitic catenas with differing effective precipitations. Ultimately, our objectives are to generate a predictive model for landscape development for the region. We will quantify rates of elemental transfers and river incision via a combination of U-Th disequilibrium and cosmogenic isotope (<sup>26</sup>Al/<sup>10</sup>Be) work. These rates will be used to parameterize a dynamic landscape model for the region, using LIDAR-derived digital elevation models to finetune our understanding of the routing of water and weathering products across these hillslopes.

I visited Santa Barbara to continue laboratory work on soil samples collected between August and November of 2004. We sampled 84 soil pits by horizon for a total of 457 individual samples for separate analysis. Each sample is analyzed for total elemental content, clay mineralogy, base cation concentration, clay percentage, pH, conductivity, cation exchange capacity.

## Survey efforts to estimate population size for African elephant conservation

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The aim of the study was to determine an optimal survey effort for accurate and precise population estimates under varying conditions of density and distribution through the use of computer-simulated aerial strip transect sampling of hypothetical elephant populations. As survey effort over hypothetical populations increased, accuracy and precision increased, *i.e.* repeated population estimates converged onto the true population size and PCLs declined to zero at 100% coverage. We found that the exponential decrease in the variances of the estimates and PCLs at each survey effort stabilized around survey efforts of 15 to 20% for almost all hypothetical populations, regardless of density or distribution (Table 1). The few regressions that indicated stabilization at survey efforts higher than 15 to 20% did so as a result of outlying variances that were not removed prior to analysis. Density affected the survey efforts needed to achieve 5% targets defined for accuracy and precision. In addition, the survey efforts required for accurate ( $t_{26}=3.22$ ,  $p<0.01$ ) and precise ( $t_{26}=8.71$ ,  $p<0.01$ ) estimates for hypothetical populations with random distributions were generally lower than those for hypothetical populations with clumped distributions irrespective of density.

These findings are of benefit to any study area where an elephant population estimate is needed. The managers at Kruger National Park, who conduct annual total counts, can benefit from knowing these optimal survey efforts, as well as their density- and distribution- dependence or independence. In addition, it is helpful for Kruger's managers to know the precision estimates for the total counts from 1995 to 2004.

**Migration and habitat selection of Luvuvhu River tigerfish (*Hydrocynus vittatus*) population in the Kruger National Park**

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To date 241 tiger fish have been tagged in the Luvuvhu River system in the KNP. Only two recaptures have been recorded. One fish was recaptured in the same pool 10 weeks after the initial capture and the second fish tagged at Magovani was caught by a fisherman 14 kilometer down stream from its original location where it was tagged. At the end of September 2004 a habitat evaluation of the reach from the Lanner Gorge to the Luvuvhu River Bridge at Pafuri was conducted.

## **Habitat requirements and selection of Large Scaled Yellow Fish *Labeobarbus marequensis* in the Crocodile River System of the Kruger National Park**

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The distribution of large scaled yellow fish in the Lowveld is decreasing at an alarming rate. Little or no scientific work has been carried out on this species. Their distribution through out the lowveld is continually under threat and this species has disappeared from then Nkomati River in the lowveld region. It is imperative therefore that this species be thoroughly researched and their habitat requirements, breeding biology and food preferences be clearly understood if the conservation and survival of this species is to be successful. They occur in the warm waters of the east flowing rivers throughout the Kruger National Park (KNP) yet are more prolific in some of these rivers than in others. Personal observations have shown that the Crocodile River has a reasonably healthy population of *Leabobarbus marequensis* and therefore is ideal suited for research of this nature. Furthermore the Crocodile River system is under continually under threat due to the potential industrial pollution, water extraction and the construction of in stream structures. The In stream flow requirements (IFR) of the Crocodile River still as yet has not been finalized and therefore the dry season IFR is of particular concern.

To date 10 Large Scale Yellow Fish (LSY) have been tagged in the study area of the Crocodile River system in the KNP. Only one recapture has been recorded. The objective of using the alpha numeric tags was to establish the possibility and viability of using these tags on the LSY fish.

**A systematic review of the Chrysochloridae based on molecular data with emphasis on the population genetics, intraspecific phylogeography in an endemic, insectivorous, subterranean golden mole species of South Africa, *Neamblysomus julianae***

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## **A Comparative study of rodent and shrew diversity and abundance in and outside the Nwashitsombe enclosure site in the Kruger National Park**

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The study is based on trapping of rodents in, outside and surrounding the Nwatschumbi enclosure site in the northern Kruger National Park, with reference to plant association, seasonal change, management practices and community dynamics of rodents. A focal point will be to establish the effect of fire, and destruction of the vegetation by elephants and large ungulates, may have on the diversity richness and abundance under different habitat, management and seasonal conditions. This research showed that certain management practices have a positive influence on rodent species diversity and abundance, while others have a negative influence. It is accepted that frequent fires result in vegetation becoming less wooded over a period of time, thus favouring rodent species which prefer open areas e.g. *T. leucogaster* and *S. pratensis*, while having a negative influence on species favouring wooded habitat i.e. *G. murinus*. The fire break surrounding the enclosure site was burnt in July 2004, with up to 100% burn in some areas. Although it was expected that the burn would have had an immediate and detrimental effect on the high *M. natalensis* population, this was not the case and numbers collected during August was in fact higher than numbers collected before the burn. Signs of a decrease in the population only occurred in September 2004. They could have temporarily fled to adjacent areas during the burn, and returned afterwards. It is expected that the population decreased gradually due to a decrease in food and cover, an increase in competition and an increase in predation as a result of a lack of cover. The population probably sustained itself by feeding on the verges of the burnt area.

## ***It's Mine, It's Yours: Archaeology and Cultural Heritage in the Park***

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One of the most volatile contexts for the shift between apartheid and post-apartheid governmental strategies is the management of national parks. My research focuses on South Africa's most famous park, as it transitions towards a new program of cultural heritage management. Kruger National Park is an international icon that represents the remarkable natural heritage of South Africa. For over a century the unique flora and fauna of the park have invited protection and conservation, institutionalized under a government mandate formalized by former president, Paul Kruger. While enormous efforts have been undertaken to protect, study and present South African natural heritage in KNP, the concomitant cultural heritage of the park has received comparatively little attention. There has been an unwillingness to separate natural and cultural heritage since the environmental tourism is so popular and lucrative. However, the naturalizing of culture and past communities, specifically in an African context, has potentially negative and racist connotations. Yet given the park's history, deeply implicated in the consolidation of Afrikaner nationalism, new developments from within suggest a new climate of inclusivity and empowerment encapsulated in the park's motto *It's mine, It's Yours*. My project tracks these changes in terms of the status of archaeology, site presentation, KNP's relations with communities and stakeholders, attitudes within SANParks and so on.

This research is timely because the past is constantly being invoked to ameliorate economic and social deprivation in contemporary South African society. Government legislation imputes that it 'helps us to define our cultural identity and therefore lies at the heart of our spiritual well-being and has the power to build our nation'. Moreover, 'our heritage celebrates our achievements and contributes to redressing past inequities. It educates, it deepens our understanding of society and encourages us to empathise with the experience of others. It facilitates healing and material and symbolic restitution and it promotes new and previously neglected research into our rich oral traditions and customs'

## Population and pack dynamics of the wild dog in the Kruger National Park

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The main objective of this project was to obtain a better understanding of the manner in which the Kruger wild dog *Lycaon pictus* population fluctuates and is regulated. Park wide photographic population surveys at five year intervals were supplemented by documenting changes in pack composition and reproductive success and following the life histories of individuals in certain radio collared packs on a monthly basis. In Kruger wild dogs are a low density species that are limited by lion densities as much as food, as lion predation is an important cause of mortality for wild dogs and lion density affects their distribution. Disease was not found to be important in limiting numbers, the Kruger population is genetically healthy and handling did not affect individual wild dogs. Wild dogs have a very high metabolic rate which could make them susceptible to kleptoparasitism from spotted hyaenas and periods of food shortage, although spotted hyaena kleptoparasitism is infrequent in Kruger. Packs generally consist of an unrelated alpha pair, sub-dominant close relatives and offspring of the alpha pair. Sub-dominants occasionally reproduce but their offspring rarely survive to one year of age. Dispersal usually takes place in single sex groups and is relatedness influences both the timing and location of dispersal events as they usually take place in association with a change in the pack dominance hierarchy and disperses often move to areas with a high proportion of relatives, although long distance dispersal sometimes occurs. The wild dog population in Kruger is given to wide fluctuation, peaking at 434 in 1995 to a low of approximately 150 in 2005. Litter size is large and variable pup survival is the most important driver in population fluctuations. Past rainfall significantly influences survival of pups up to nine months, such that pups benefit from preceding dry periods.

## **The impacts of off-road driving and other concessionaire activities on physical soil degradation**

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Due to the fact that the objective of my research to “quantify the impacts of off-road driving on physical soil degradation” in the private concessions can only be done properly over a relatively long period of time, I have decided to do the research in three separate phases. As part of the guidelines for ORD, set by KNP, it should be included that no ORD further than 50m would be allowed, no matter what the conditions. The most important step is the assessment of land use pressure (off-road driving) on soil in terms of soil carrying capacity and the driving forces for land use. Under a balanced condition, Best Management Practices may help ensure that sustainability is maintained. The indicator system is ideal for application in all areas at risk of water and wind erosion as well as soil compaction. Hotspots (areas that have potential for soil degradation) and coldspots (areas that are suitable for off-road driving) can be estimated in this way and with the help of statistics. The results can be used by the concession’s management and the Kruger National Park Conservation Services to effectively manage the concession’s area. Though, the suitability analysis was successful, further research is necessary to test the validity of the methods used in the analysis.

Research was also started in June / July at the KNP low-usage management tracks and it is planned to do some work on the Lebombo Eco-trail in September 2005 – these form part of the second phase of the research. Phase three will include the final quantification of the effect of off-road driving on physical soil degradation, and it is foreseen that this final phase of the project may extend.

## **A survey of the composting fungi in a mopani landscape and the effect of different fire regimes on their species composition**

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The Kruger National Park (KNP) has conducted studies on different fire regimes for the past 51 years, but the effect of these fire regimes on fungal populations has not been studied. The National Collection of Fungi has no records of fungi on, or surrounding, *Colophospermum mopane*. It was therefore decided to conduct a survey of fungi in the mopani landscape in the KNP. Samples were collected from the experimental burn plots before burning and directly after; the latter to establish what fungi from the different samples survive the fire. These samples should indicate whether the composition of fungi changes in the months subsequent to a burn. Preliminary results include that lichens were mostly absent from the burn plots, but present in the control plot. When present in a burn plot, it was only noted on trees close to the edge of a plot. This might indicate that lichens need at least four years to re-establish after a burn. *Xylaria* species were only recorded from humid chambers in which plant material and in one case, debris, from the control plots were plated out. These species were not present in the burn plots from the October four-year burns. A *Fusarium* sp., as yet only recorded from grasses in Australia, was isolated from debris from the control plot. The complete identification of this fungus is being investigated further. *Paecilomyces lilacinus*, *Aspergillus niger*, *Aspergillus fumigatus* and *Trichoderma* spp. were consistently present in both the pre-burning and control samples from soil from the October four-year burn plots.

## **Transformation of a riparian forest to open woodland on Greefswald, Mapungubwe National Park**

O'Connor T<sup>1</sup>

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This study examined mortality and compositional change of the canopy component of the Greefswald riverine forest between February 1990 and February 2005. Key aims were to determine whether water extraction or elephant had deleteriously impacted the forest canopy. Baseline measurements were taken in February 1990 before water extraction for the mine commenced. Key events thereafter were the cessation of flow in the Limpopo River over the 1991/2 season, the February 2000 flood, and an increasing density of elephants from about 2000. 434 canopy trees between the Shashe-Limpopo confluence and Poachers Corner were tagged in 1990, with measurement of size, condition and drought dieback. Almost all trees were accounted for in 2005, when elephant impact, not apparent in 1990, was also measured. In summary regarding the canopy component, water extraction exacerbated the impacts of the 1991/2 drought, elephant have not been but will likely become an agent of change, and creepers exert an influence on forest dynamics. It is recommended that if adverse effects of water extraction are to be precluded in the future, appropriate vegetation monitoring needs to be incorporated into managing water extraction.

## **The influence of different precipitation levels on germination of grass species in a lowveld savanna**

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Four veld condition sites have been pre-selected in the vicinity of Lower Sabie in the Knob thorn Marula Parkland vegetation type, on each of the following geological formations: Granite, Basalt, Ecca-shale and Lebombo-riolite. During the germination trial a total number of 3 different grass species have germinated in varied germination opportunities altered by possible temperature and soil water regimes. Species cannot be identified as yet to a species level, as the seedlings have only reached their second leaf growth stage and no inflorescences have appeared as yet.

## **Grazing capacity determination using herbaceous layer phytomass**

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The main objective of the study is the refinement of grazing capacity, using three techniques. These techniques are the determination of standing biomass by using the disc pasture meter, the plant number scale and the key species method. These techniques will then be compared to one another. Together with the 14 key species, technique Trollope (1990), all the species closest to the point were identified. The species recorded were divided into closest annual, closest perennial closest biennials and closest forb. This will give the veld and the land use manager a more accurate score concerning the determination of grazing capacity, because there is a bigger variety of species that is recorded and not just the 14 species. The cutting of grasses under the disc was used in conjunction with the plant number scale to determine if there is a correlation between the two different technique's determinations of biomass. The phytomass data generated from the cut plot method can then be compared to the phytomass data generated using the plant number scale regression. It is assumed that the cut plot method will give a value that will be more accurate of the actual above ground phytomass, because the cut plot method is an actual cut and weigh method and not an estimate. Data collected using these three techniques will be analyzed and grazing capacity determination will be refined.

## **Ant diversity and distribution in KNP: developing bioindicators**

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The aim of this project is to sample ants from southern habitats of KNP to enable better understanding of the biogeography of the ants of KNP. Sampling has been conducted and ant samples will be identified and counted at the CSIRO TERC laboratories in Australia. Representative voucher specimens will be returned to the herbarium in Skukuza.

## Patterns of post-flood riparian vegetation response in the Sabie River

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The aims of the project are to 1) examine the pattern of vegetation in the Sabie River 4 years after the flood and 2) examine the influence of hydrology, riverscape heterogeneity and channel morphology on post-flood vegetation response. We measured a total of 21 373 plants within the 24, 30m wide transects. Of these, 6399 (30%) were residual plants that survived the flood and 14974 were new plants that established after the flood. We collected a total of 158 species: 128 residual species and 146 new species. Thirty of the new species don't occur as residuals and 12 of the residual species don't occur as new species. We collected 10 alien woody plant species representing 5.5% of all individuals. Most alien plants established after the flood, with the most common aliens being *Lantana camara* and *Sesbania punicea*.

There was no distinct pattern of patches at the channel type scale because the proportional area of each patch type was similar across all of the channel types. However, patch area was strongly dependent on elevation. Patches that changed state were proportionally dominant at the lowest elevations, but decreased in area at higher elevations to be replaced by patches that stayed in a vegetated state. The area of debris patches peaked at an intermediate elevation of around 2 - 4m. Thus, different patch types are available at different elevations, indicating that there is strong vertical zonation in the patch mosaic. Most residual and new vegetation occurs in patches that stayed vegetated, but smaller amounts of vegetation occur in patches that changed state in some channel types. Nested within each channel type is a pattern of residual and new plant abundance by elevation, with most vegetation occurring in changed patches at the lower elevations and in unchanged patches at higher elevations. This suggests that the channel type scale is important as a constraining level for elevation-related vegetation responses to the patchiness generated by large infrequent disturbance.

## **Towards a predictive understanding of savanna ecosystem dynamics in the Lowveld of the Mpumalanga and Limpopo provinces**

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The ARC-RFI ecological monitoring programme assesses vegetation conditions annually at some 540 sites in the protected areas of Mpumalanga and Limpopo Provinces. This section is in the unique position of having collected vegetation data, on both sides of the boundary, since the western boundary fence of the Kruger National Park was dropped. In addition the RFI has continued with the involvement in the ecological monitoring programme in the Limpopo National Park of the TFCA. The data will be valuable in detecting vegetation trends in the study area and the knowledge thus gained, is used to provide guidelines for the efficient management of the savanna areas of the Lowveld. Helen Farmer, a PhD. candidate, will look at Landscape Function Analysis (LFA) as related to water provision from the densely watered areas to the west of KNP, through the KNP and into Mozambique. Ed Wittkowski will supervise the project assisted by myself (MP). Nine students from the Department of Agriculture have been trained in LFA by Drs. Rina Grant, Allan Anderson and Alaric Fisher.

## **Coccidia of buffalo in the Kruger National Park**

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The objective of this study is the molecular characterization and identification of *Eimeria* species that occur in African buffaloes. The first stage of the investigation is the molecular characterisation of bovine *Eimeria* species, to be used for later comparison with material derived from African buffaloes. For both bovine and buffalo samples, the following will apply, the morphological description (based on size) of *Eimeria* oocysts from both bovine and buffaloes. The establishment and/or refinement of molecular techniques. This includes the optimisation of DNA extraction techniques (for improved DNA quality and volume, the faecal samples will be processed to purify and concentrate the oocysts and remove as much faecal material as possible) and the designing of *Eimeria*-specific 18S rDNA primers. The cloning of PCR products and sequencing of the 18S rDNA, and the phylogenetic analysis and description of new *Eimeria* species.

## **The influence of large woody debris and the interaction with large herbivores and fire on riparian vegetation dynamics on the Sabie River, Kruger National Park, South Africa**

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This progress report summarizes a particular aspect that has been completed of the overall study of the ecological role of the woody debris on the Sabie River. This project investigated whether LWD piles create resource nodes which can contribute to the recovery of riparian vegetation and also add to the heterogeneity and resilience of the river environment. Disturbance such as flooding can cause the re-organization of resources and add greater complexity to the system. On the Sabie River, a 100 year return flood in February 2000 resulted in the deposition of substantial large woody debris (LWD). We examined the micro-environment within LWD piles and compared this with conditions in adjacent reference sites that contained no LWD. Soil nutrient concentrations were significantly higher in LWD piles compared with the reference plots (total N +19%, available P +51%, and total C +36%). Environmental variables within LWD piles and reference sites varied according to landscape position in the river-riparian landscape and the LWD pile characteristics. These differences were generally between piles located in the terrestrial and riparian areas compared with piles located on the macro-channel floor. After 3 years the number and cover of woody species were significantly higher in the LWD piles. This was consistent across all landscape positions and for different pile types. We conclude that LWD piles left after a large flood act as resource nodes by accumulating fine sediments, soil nutrients and soil moisture. The subsequent influence of LWD deposition on riparian heterogeneity can be discerned at several spatial scales including within and between LWD piles, across landscape positions and between channel types. LWD piles are influential at the initial developmental stage of the riparian vegetation as the system regenerates following a large destructive flood.

## **Towards catchment water security through linking water and livelihoods: contributions towards constructing a socio-ecological system (SES) of the Sand River Catchment**

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This project set out to pilot the Socio-ecological Systems (SES) approach in understanding the relationship between catchment water security and livelihoods in the Sand River Catchment, and from this to assess its potential value for further use in South Africa. We have assembled most historical datasets and drawn up appropriate timelines for various zones stretching over 100 years. These have been helpful in constructing a general adaptive cycle (sensu Holling) which turns out to be most feasibly related to political events. In other words the water-livelihood axis was influenced over this period mainly by political issues, although other important co-drivers (such as economic demand for forestry) were described.

We have drawn provisional qualitative systems dynamics diagrams (sensu Allison) for the economic, socio-political and biophysical subsystems, each of which had “links” or connecting variables to the other subsystems. We opted for this rather than trying to construct one holistic “mega-diagram” at the outset, and will therefore develop a sense of the utility of this vs the alternative: in a related AHEAD exercise, but over the whole Greater-Limpopo Transfronteir Conservation Area) we opted for one diagram from the outset. The need or non-need to draw a separate diagram for different eras and different zones highlights how much or how little the system function has altered qualitatively. This becomes key information in the understanding we need. The most volatile subsystems are the socio-political ones, probably indicating that more alternate states with different overall functioning existed in that domain, at the scale examined. Finally, we constructed specific systems diagrams linking ecosystem function and ecosystem services, recognizing that some of these overlap entirely.

## **The Phabeni gate project in the Kruger National Park: a case study of community-based conservation**

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The Phabeni Gate in the Kruger Park has been successfully completed but the process of negotiation with the local community is not documented. It is a worldwide need to incorporate social sciences and conservation. Success stories should be documented to illustrate the value of social scientific information to “on the ground” conservation results. Success stories foster organizational learning, internal support, and conservation success. This will be an attempt to address a worldwide need, and will benefit the KNP and SANParks due to the successful cooperation with the local community. The Human Benefits Objective of the KNP (VOLUME VII. AN OBJECTIVES HIERARCHY FOR THE MANAGEMENT OF THE KNP, 1997) involves establishing a sense of partnership between the KNP and its neighbors and the Phabeni Gate Project is a good example thereof.

The formal empirical investigation has not started as yet because the I am still busy with the pilot study with the main focus on literature review and familiarizing myself with the history of Kruger and the new focus on the involvement of communities. The role and nature of social ecology as well as the eco-social approach, a new approach in the field of Social Work, is currently investigated.

## **Interference potential of the alien invasive plant *Parthenium hysterophorus* with indigenous plant species in Kruger National Park**

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In the current growing season the tolerance of the three indigenous grass species (*Digitaria eriantha*, *Eragrostis curvula*, *Panicum maximum*) towards parthenium was assessed in a system where the grasses were in their second growth season (est. January 2004) before the re-introduction of parthenium occurred.

Of the three indigenous grasses assessed, *P. maximum* performed the best as regards inherent growth rate and ability to suppress parthenium growth. Although *D. eriantha* outperformed *E. curvula*, both these species performed poorly in comparison with *P. maximum*. The high tolerance of *P. maximum* towards parthenium is attributed to inherent vigour and robustness, and better adaptation to the environment conditions, especially to soil pH. *E. curvula* and *D. eriantha*, which are known to prefer more acidic soil conditions, showed better growth performance in the second (2005) growth season, indicating better adaptation to the environmental conditions after a longer establishment period. The suppression of parthenium growth, the cause of parthenium seedling mortality on *P. maximum* plots, and good seed production by the grass when co-existing with parthenium, demonstrate this species' high potential for use as an antagonistic species in a biological control program. Results also suggest that antagonistic species should be selected according to environment compatibility in addition to interference potential with the invader plant. As *P. maximum* is a highly palatable grass, high grazing pressure could influence its interference potential with parthenium under natural conditions. *P. maximum* is known not to tolerate intensive, frequent grazing. Findings suggest that any vigorous grass component, which provides good ground cover, will likely provide resistance to parthenium encroachment of an area. Good veld management practices that promote the grass component are likely to be beneficial in this regard. To the best of our knowledge, parthenium is not eaten by any herbivores, and therefore, excessive herbivory stress that is exerted on the grass component will likely promote the spread and fecundity of parthenium.

## **A study of fungal pathogens on native tree species in Kruger National Park**

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The project proposal submitted in 2004 included two components. The one was to conduct general disease surveys of trees in KNP. The second part was a study of fungi infecting wounds created by elephants. One report was received of white growth on *Ziziphus mucronata*. This was identified as a fungus called *Coniodyctium chevaleri* and the disease was monitored during 2004 and 2005. Findings to date suggest that the fungus does not pose a serious threat to the survival of buffalo thorn.

Two surveys of wounds on trees caused by elephants in the area around Skukuza have been conducted. The wounds from which successful isolations were conducted were in general between five to twenty days in age. Samples were collected from *Acacia gerardii*, *A. nigresens*, *Albizia petersiana*, *Combretum apiculatum*, *C. hereroense*, *C. imberbe*, *C. zeyheri*, *Diosporys mespiliformis*, *Euclea divinum*, *Lannea stuhlmannii*, *Peltophorum africanum*, *Philenoptera violacea*, *Sclerocarya birrea*, *Schotia brachypetala*, *Terminalia sericea* and *Ziziphus mucronata*. An unknown species of *Ceratocystis* and *Ceratocystis albifundus* were the two most common fungi isolated on the wounds. Signs of other *Ceratocystis* spp. and *Ophiostoma* spp. were also present but attempts to isolate them were unsuccessful during these two surveys. DNA sequence data has confirmed that a previously undescribed *Ceratocystis* sp. is present in KNP. This fungus was commonly found sporulating on the wounds. We are currently conducting morphological characterization and description of this fungus. The potential of this fungus to cause disease is unknown and will be determined in future. *Ceratocystis albifundus*, the other commonly isolated fungus is a serious canker and wilt pathogen of exotic *Acacia mearnsii* trees in South Africa. It is also common on native tree species around the Pretoria area and pathogenicity tests in the greenhouse have shown that it can result in the death of *Combretum molle* and *A. caffra* trees. It is hypothesized that *C. albifundus* is native to South Africa, but to prove this hypothesis a population of the fungus from native hosts is required. Research to date has confirmed that *Ceratocystis* spp. infect wounds of a number of native tree species in KNP. Some of these fungi are new to science. We now need to determine the role of these fungi in the decline or recovery of damaged trees.

## **A GIS Model of bovine Tuberculosis in the African Buffalo (*Syncerus caffer*) population of Kruger National Park, South Africa**

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The objectives of the project were to create a GIS model of buffalo response to climate and habitat, incorporating demographically driven age-structured disease transmission. To assess management strategies (vaccination, culling, exclusion zones) within this GIS modeled environment of Kruger National Park. To provide Kruger National Park with information and data regarding modeled strategies, habitat data and crucial demographic data for African Buffalo. The information and results of this dissertation, in combination with ongoing work will help inform models of the disease as it moves through buffalo on the landscape. It highlights that buffalo do respond to measurable differences in the landscape; both the spatial and temporal distribution of resources affect their distribution and demography considerably. The remotely sensed vegetation index, NDVI, proved to be useful as a surrogate for habitat quality, both spatially and temporally, but not at the high resolution we had hoped. This can mean two things: 1. if we want to model the landscape at a finer scale, a better measure of landscape quality, from a buffalo's perspective, should be developed; or 2. since a larger scale index is a reasonable surrogate, we can use coarser data, but must adjust the scale of management implied.

At this point, a model operating with the parameters established for buffalo-habitat relationships in this dissertation, coupled with demographic parameters specific to this area for buffalo could be implemented in a spatially explicit dynamic software package such as NetLogo©. However, to incorporate site-specific disease dynamics in an appropriate manner is not yet possible. Thus I would not recommend constructing such a model for management purposes until further data analyses from the Satara monitoring are complete.

Additionally, it is important to note that since the outset of this study, a number of other species have been implicated in the potential spread of Bovine tuberculosis within KNP; thus a model incorporating those species – a multi-host model of spread – would be most appropriate.

## **Dung beetle richness, dung preference and assemblage structure in the Kruger National Park**

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## **The role of artificial waterholes in nutrient redistribution in the Kruger National Park**

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The aim of this study is to investigate whether grazing gradients radiating from artificial waterholes give rise to nutrient accumulation in close proximity of artificial waterholes. This is done by comparing nutrient status in soils and in leaves of a common palatable grass species, *Uroclea mosambicensis*, at increasing distances from waterholes on clayey and sandy soils respectively. Distance from waterholes, or features associated with distance from waterholes, have an effect on nutrient distribution in the landscape, both in the soil and in the grass samples. In general, nutrient levels in the topsoil as well as in *Uroclea mosambicensis* leaves are elevated close to waterholes. On a  $\leq 5\%$  level of significance, nutrient levels close to waterholes are higher for  $K^+$ ,  $Na^+$  and  $NO_3^-$  in the soils and for N and  $Na^+$  in the *Uroclea mosambicensis* samples. Furthermore, *Uroclea mosambicensis* samples collected close to waterholes have higher  $Mg^{++}$  and  $K^+$  concentrations compared to samples collected further away (approaching statistical significance - 10% level of significance).

## Using Isotopic Evidence of Large Mammal Nutritional Ecology to track vegetation change through time

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The aim of this project is to study the ecology of large mammals in Kruger National Park, with the ultimate goal of reconstructing its historic environments through stable isotope analysis. Three winter and three summer field sampling have been completed, during which we collected plant and fecal samples. Our modern study has demonstrated that our isotopic ecology technique is well suited for determining dietary differences within species in different areas of the park. Stable isotope analysis of both feces and hair have shown, that during the dry season impala browse more in Mopane-dominated northern Kruger (~60%), than in southern Kruger (~30% browse). More recent data have shown, that there are dramatic dietary differences between impala on basalt and granite substrates, even when separated by less than 10 kilometers. Furthermore, analyses of hair from known individuals have demonstrated that male impala graze about 14% more than females. Elephants, in contrast, graze more in northern Kruger (~35% grass) than they do in the south (~20% grass), and indeed had diets comprised predominantly of grass during the rains of 2002.

Our research on rare species like roan and sable antelope has also provided interesting results. Our fecal data demonstrate that the Northern Plains roan eat grass nearly exclusively, and that their fecal 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 to be a near exclusive grazer, though our data indicate a notable increase in browse seasonally. Sable also has very low fecal nitrogen concentrations (~1.0%), but not as low as those of their congener the roan.

With this considerable modern data set in hand, we have also begun preliminary research on the diets and habitats of historic elephants within KNP. Both hair and ivory from a number of elephants that lived in the park during the last century were analysed. Results demonstrate large scale seasonal diet change within individual elephants. She has been able to document a 40% increase in the consumption of grass in some elephants since the 1970s, although new data reveal a variety of different patterns. Additional tusk data to address these issues will be available in the coming months.

## **Global climate change and primary productivity: the effect of inter-rainfall interval on grass growth**

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The productivity of grasslands and savanna is primarily determined by the response of the dominant grass species to rainfall. Both rainfall amount (total annual rainfall) and rainfall timing (within the growing season) may affect grass community productivity, and both are predicted to change significantly over the next 50 years as a result of global climate change. The primary aim of this study is to determine the magnitude of variation in the above-ground growth responses of dominant grass species to rainfall, for a range C<sub>4</sub> grass communities. A secondary aim to determine how grazing affects such variation. Research is being done at seven sites, three of which are located within the Kruger National Park. Above-ground growth is being measured by means of clipping target plants at regular intervals through the growing season. Repeated clipping is used to simulate the effects of grazing. Soil moisture is being measured at 3 depths at each site. Preliminary results for the 2003/04 and 2004/05 summer indicates significant variation between species, in terms of short-growth responses to soil moisture and clipping. These results were presented at the 3<sup>rd</sup> KNP Science Networking Meeting.

## **Modelling buffalo - lion interactions and implications for the spread of bovine tuberculosis in Kruger National Park, South Africa**

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We aimed to test the applicability of using aggregated GPS points in space and time for the location of lion kills, in particular large kills such as buffalo. We further aimed to calibrate the signal strength data obtained from the active tags with field observations to determine the distance between lions during aggregations of co-ordinates. For the purpose of the study we defined an aggregation in time one or more consecutive hourly GPS readings within 100m of the previous GPS reading fixed one hour earlier. The value of 100m was used because GPS error during the test phase was greater than 50m in a few occasions but never exceeded 100m, even when under thick foliage. One hundred metres was therefore used, but this could be modified to 50m if necessary. Kills were located primarily by investigating aggregations in time, with 42% of all aggregations (n = 105 between 20<sup>th</sup> May 2005 and 17<sup>th</sup> August 2005) investigated on foot. A large proportion of the aggregations (31% of all aggregations) were two point aggregations that meant that the lions were stationary in one spot for approximately one to two hours. The majority of one hour aggregations were not followed up and attention was given to following up almost all the night-time aggregations. Through this method, as well as by using a ratio between the distance travelled before and after an aggregation, 19 kills have thus far been located, averaging a kill every 4.5 +/-1.9 days (minimum = 1 day, maximum = 8 days).

## ***Salvadora australis* as an ecosystem engineer of sodic sites in the northern Kruger National Park**

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This study has established the importance of this ecosystem engineer in creating habitat heterogeneity and increasing biodiversity of sodic sites which are often seen as unproductive elements in the landscape. It has also highlighted the heterogeneity of the sodic boundary between riparian and terrestrial ecosystems by exposing the complex interactions between soil, water movement, vegetation and animals that take place in these systems. The mission statement for the Kruger National Park is 'to maintain biodiversity in all its natural facets and fluxes' The outcomes of this study demonstrate how biodiversity is enhanced by one organism, and thus have important conservation and managerial implications. In adopting this mission of Kruger it has become important to identify key agents and controllers of heterogeneity that managers can manipulate if they need to influence the nature and direction of heterogeneity and this study has identified such an agent, and the processes it modifies.

## **Rapid assessment of the population demography of elephants in the Kruger National Park**

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We have a dual interest in the dynamics of the elephants that live in the Kruger National Park. The first stems from the value that population variables may have for managers in conservation. The second focuses on our academic interest to study the spatial forces that may limit elephants across their distributional range. Information on the birth and death rates also provides an opportunity to calculate intrinsic growth rates independent of counts. Counts have inherent biases that detract from their value in calculating growth rates. For instance, the Kruger elephants increased at 6.6% in numbers per year during a period when they were confined. At the same time the estimates of survival and reproductive outputs predicted that their numbers were only increasing at 2.5% per year. Such discrepancies confuse the decisions that managers have to take when designing conservation actions. Our project thus focuses on extracting age-specific survival and reproductive rates to model population growth rates for the elephants in Kruger.

Three days of helicopter surveys in May 2004 with the assistance of SANParks enabled us to cover most of the area from just north of the Crocodile River to just south of Punda Maria. Two weeks of ground-based surveys were completed during September 2004. During both these surveys we used a Canon 10D single-reflex digital camera with a 70-200 mm Canon F4 lens to make 10 to 20 digital images of each of the elephant herds we encountered. We determined individual relationships and grouped elephants into one of 15 age classes.

During September 2003 the number of elephants in Kruger was 11672 of which we sampled 641 in 41 herds from the air. Herd sizes then ranged from 2 to 57 individuals with a mean value of  $16 \pm 2$  (S.E.) elephants. During ground-based surveys we sampled 274 elephants in 19 breeding herds and 40 bull groups. Herd sizes ranged from 5 to 39 with a mean value of  $14 \pm 2$  (S.E.) elephants. We have extracted the age distribution for these two surveys in Kruger and have developed a method to smooth the distributions.

## Assessing and monitoring local scale impacts of *Opuntia stricta* on arthropod assemblages in the Kruger National Park, South Africa

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This project aims to investigate the degree of change in invertebrate assemblages as a result of alien plant species invasions in KNP. More specifically, habitat specificity of dung beetles and spiders and variation in these assemblages, within a habitats characterized by different levels of *O. stricta* invasions, will be examined. Second, groups of species characteristic of each plant invasion level (indicators), as well as species that may be used to monitor changes in invasion levels (detectors) will be identified. Detector species will be used to predict change in the intensity of plant invasions. Third, should these detector species successfully predict any change, the option of using these species to rapidly predict the biological impact on invertebrate assemblages at feasible “maintenance” levels will be explored further. Feasible “maintenance” levels or theoretical low invasive levels are levels identified by the KNP management services at which the follow-up control of invasive plants is most efficient from an economic point of view. However, the biological impacts at these theoretical low levels are currently unknown. The research questions asked will form part of the park’s long-term strategy to manage invasive alien species. Consequently, this study will take the form of simultaneously addressing pure scientific questions as well as basic conservation management needs. Four different habitat areas characterized by three different levels of *O. stricta* invasion (high; intermediate; no infestation and pristine) have been identified. In each of these, five replicated sampling sites will be selected from which the volume and ground cover of *O. stricta* patches will be determined. Within each sampling site, spiders and beetles will be collected bimonthly over a period of 12 months (i.e. six temporal replicates) using un-baited pitfall traps. In the case of spiders, additional sampling will be conducted using leaf litter sifting and active searching. To date, only one monthly sample has been completed (14<sup>th</sup> July- 14<sup>th</sup> August 2005) and I am currently busy identifying samples and sorting them out into morphospecies. Therefore no data is presently available.

## **The role of cloven-hoofed animals in the epidemiology of foot-and-mouth disease**

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Foot-and-mouth disease (FMD) virus causes the most economically important viral disease of animals. The outbreaks of FMD during 2000/2001 indicated the devastating effects it could have on agricultural production and loss of export markets for agricultural products in specific regions as was demonstrated during the outbreaks in Kwa Zulu/Natal (2000/1), Mpumalanga (2001) and Limpopo (2001 and 2004). The Kruger National Park (KNP) is a FMD endemic area and one of the major tasks of the Directorate of Veterinary Services is to implement measures to prevent the escape of the virus to adjacent domestic animal populations. It is established that buffalo in southern Africa maintain the SAT types of FMD virus but precisely how they are maintained within free-living buffalo populations and the mechanism by which they may be transmitted from buffalo to domestic stock are not clearly understood and are studied in this project. The recent outbreak in the Limpopo province in regions surrounding the KNP was shown to be caused by an isolate similar to buffalo viruses investigated in the KNP previously, as was found with the outbreaks that occurred during 2000/2001. The impala is considered as an indicator species for FMD outbreaks occurring in the KNP and for this reason a sero-surveillance program is in place to detect the spread of FMD to this species. Furthermore, monitoring the variability and antigenic range of FMD field strains is crucial to ensure that vaccines in current use in the endemic zone that borders the KNP are effective.

The aim of this study is to use serological surveys to determine the possibility of persistent infection in impala as well as the level of sub-clinical infections. In comparison with previous years, sampling was less frequent and involved a lower number of samples for the reporting period, making accurate comparison difficult e.g. the detection of sero-conversion in the Shingwedzi area is based on 1/43 animals tested in the area and may not be a significant finding. One hundred and seventeen sera were collected from buffalo in the Disease Free Buffalo project at Skukuza and 9% had antibodies to SAT 1, 21% to SAT 2 and 16% to SAT 3. The findings do not have significance as all the sero-positive animals were calves borne to infected dams indicating maternal antibodies as the likely source of the serological status.

## **A study of the characteristics of *Nothobranchius* fish habitats in the Great Limpopo Transfrontier Park and the geological factors controlling their distribution**

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The objective of this research is to study the characteristics of *Nothobranchius* fish habitats in the Great Limpopo Transfrontier Park with an emphasis on the geological characteristics of the habitat substrates and the geomorphological factors controlling their distribution. The Pumbe Picket *Nothobranchius* habitat in the KNP is part of a more extensive system of seasonal pools in the immediately adjacent part of Mozambique. This discovery is of particular significance from a conservation point of view because it is now almost certain that the populations of *Nothobranchius* fishes are locally more extensive than was previously thought. This system of seasonal pools was mapped in detail using GPS techniques.

The elevated area on which the seasonal pools at Pumbe Picket are situated, apparently drains eastwards into the Mazimechopes River system, to the immediate south of the GLTP in Mozambique. During the 2004 field work, we discovered three localities of *Nothobranchius* fishes on the Mazimechopes River floodplain. All three sites included forms of *N. rachovii* and *N. orthonotus* having color patterns identical to those of the same species present at the Pumbe Picket locality. These close similarities, when considered in the light of the geomorphological evolution of the area, indicate that these species once populated an ancient land surface, an elevated remnant of which now hosts the Pumbe Picket locality. Denudation of most of this ancient land surface resulted in a lowering of the general landscape, the *Nothobranchius* populations being redistributed at a relatively lower elevation everywhere except at Pumbe where the highly resistant rhyolitic bedrock inhibited downward erosion of the land surface.

*Nothobranchius furzeri* was also found at two of the Mazimechopes locations. The fact that *N. furzeri* is found only on the modern floodplain areas at relatively low elevation, and not on the ancient floodplain (or peneplain) remnant, suggests that this species evolved later than the denudation event and, therefore, later than both *N. rachovii* and *N. orthonotus*. The fact that the distribution of *N. furzeri* is, in general, very much more restricted than that of the other two species, supports this contention. The ancient erosion surface/peneplain in the Pumbe area is probably Late Tertiary in age and the overlying deposits of cobbles, pebbles and sand, on which the mud substrate of the Pumbe locality occurs, are of Quaternary age. This in turn suggests that the two older

species dates back at least 2 million years while the development of *N. furzeri* would be substantially younger than that.

Field investigations in the southwestern part of the Coutada 16 part of the GLTP in Mozambique, bounded by the Olifants and Shingwedzi rivers, indicated that this area was probably not suitable for *Nothobranchius* habitation. The seasonal pools investigated had a substrate that was too sandy and lacked the necessary fine mud base.

While recent field work (2005) in the northern part of the Coutada 16 area was hampered somewhat by drought conditions. Nevertheless, numerous seasonal pans (dry) having thick black mud substrates were found on the floodplain immediately to the west of the Limpopo River in the Mapai area and we feel sure these must host *Nothobranchius* fishes. West of the Limpopo River floodplain in this region, seasonal pools tend to have similar characteristics to those in the adjacent Nyandu Sandveld of the KNP in that their substrates are generally too sandy or thin to support populations of *Nothobranchius*.

Substrate samples collected during the 2004 and 2005 field seasons are presently being subjected to detailed mineralogical analysis (by X-ray diffraction) aimed at identifying the dominant types of clay minerals present. Observations in the field and laboratory work carried out to date have, in a preliminary fashion, confirmed our premise that the clay minerals in viable *Nothobranchius* habitats are dominantly of the swelling variety.

## **Censusing and monitoring the herbivorous large mammal population of the Kruger National Park using aerial transects surveys (ALT's)**

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The use of fixed-wing aircraft for surveying of the larger herbivores (excluding elephant, rhinoceros and hippopotamus) was initiated in the Kruger National Park (KNP) in the early 1970's. But first count attempting total coverage of the whole area of KNP was conducted in 1977. Due to the large size of KNP, these surveys took 3½ months to complete each year. This precluded repeated surveying or repetitions and so the statistics surrounding the data sets (variance, confidence intervals etc.) could not be calculated. Data from these counts were therefore accepted "at face value", and it was also accepted that trends observed in census totals reflected actual population trends. With current priority shifts and the logistics surrounding the old EAS method have enforced a re-evaluation of the census programs in KNP. The objective of the project was to monitor population trends of the common larger herbivores (impala, giraffe, kudu, wildebeest, waterbuck, white rhino, zebra, steenbok and warthog) in the Kruger National Park. It was felt that the sample size of 22% was too small, coverage was increased to 27% in 2004 by extending the search area from 400m to 500m away from the aircraft. This did not prove satisfactory as the visibility of animals more than 400m from the aircraft was very poor, and little advantage was gained. Variability in the results (particularly 2001) suggest that we still have not yet achieved the accuracy and precision required.

## Aspects of the ecology of buffalo (*Syncerus caffer*) relevant to the management of the Kruger National Park population

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Between 1967 and 1991, the Kruger National Park (KNP) buffalo population was subjected to a large amount of management effort to keep the population below 30 000. Culling quotas were allocated on the basis of this fairly arbitrary population ceiling. This method was successful in maintaining the population at around that level, but between 1981 and 1984, and again between 1991 and 1995, major declines were recorded as a result of severe droughts experienced in the KNP. As a result of these declines, buffalo culling was terminated (in 1991) until it had regained a level above the prescribed minimum ceiling (22 000).

The aims of the study were to monitor the population dynamics of the population, to assess the impact of buffalo herds on the habitat as well as the effect of deteriorating habitat (as during droughts) on the population, and to determine the potential effects of BTB on the dynamics of the buffalo population. This year the population finally showed the increase which could have been expected from the conditions which have prevailed for the past few years. The recorded increase of 19.8% was from 23 778 to 28 489. A total of 2 958 calves (10.4%) were counted, and the bachelor segment of the population also increased by 24.7% to 1 050 from the 842 recorded last year. The population is now almost back to the levels recorded prior to the crash that was induced by the droughts of the early 1990s. Many of the herds, particularly in the Far-northern Region, had fragmented into smaller groups which was contrary to expectation as grazing was apparently in good supply due to the above average rains received in the late in the previous summer. In contrast, many large herds of over 800 were also encountered.

The breeding herds segments of the buffalo populations of the respective Regions also all followed similar trends to that of the population as a whole. Severe declines occurred as a result of the droughts of the early 1990s, but all have increased with the advent of better rainfall, but the rates of increase have not been equal in all Regions. The *intrinsic rates of increase* ( $r$ ) for the breeding herd segments of the respective regions were: Far-northern Region:  $r = 0.091$ ; Northern Region:  $r = 0.107$ ; Central Region:  $r = 0.048$ ; Southern Region:  $r = 0.041$ . These growth rates reflect the known prevalence rates of btb in these regions – the lowest growth recorded in the highest prevalence region and the best growth was in region with the lowest prevalence.



## **Aspects of the ecology of elephant (*Loxodonta africana*) relevant to the management of the Kruger National Park population**

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The Kruger National Park (KNP) elephant population received a large amount of management attention over between 1967 and 1994. This was due to the fact that persistent population increases were considered to be a threat to the KNP's habitats in terms of both the water resources and the possible (probable) modification of plant communities. It was envisaged that such a modification could take the form of either changes to the structure or the composition of such communities or both, or in its most extreme form, local extinctions of certain favoured and vulnerable plant species (such as baobabs). In spite of this potential threat, relatively little is known about the long-term dynamics of the population or its responses to climatic cycles. Another little known aspect of elephant ecology is their movement patterns under normal circumstances compared to those resulting from the disturbances of culling operations. The aim of the study was to monitor annually and over the long-term, the dynamics of the elephant population from census data.

The annual census of 2004 was conducted between 24-08-2003 and 13-09-2003. This census yielded a population estimate of 11 454 elephants of which 9 760 (85.2%) were breeding herd animals and 1 694 (14.8%) were adult bulls. The calf percentage recorded was 3.7% of the population (420 calves of under one year of age). This total is up by 1 213 on last year's census total of 10 459. As was the case in 2000, this year's census again suggested a decline when compared with that of the preceding year. The apparent decline is again ascribed to the conditions prevailing during the census. The KNP received above average rainfall again this season, and the majority of this rain fell late in the summer. This created extremely wet conditions at the time of the census, and the trees had not begun to lose their leaves and were still in a full summer aspect. This would have considerably affected visibility, resulting in a poor count. Another possible factor was the opening of the eastern boundary fence. It is known that some elephants have started moving between KNP and the Limpopo National Park (LNP), but the numbers involved are as yet unknown as no census of the LNP area has yet been conducted.

## **Hippopotamus population monitoring in the Kruger National Park**

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In the past, South African National Parks (SANP) conducted an annual censuses of the hippopotamus populations of all the Kruger National Park's (KNP) rivers (Limpopo, Luvuvhu, Shingwedzi, Letaba, Olifants, Sabie and Crocodile rivers). Responsibility for hippo monitoring was passed to Dr Ian Whyte in 1998. Due to the escalating costs of such censuses, it was decided at a planning workshop held in early 1998, that each river would only be censused every third year. This meant that in any one year, one of the river complexes would be censused. These three complexes are the Limpopo/Luvuvhu/Shingwedzi, the Letaba/Olifants and the Sabie/Crocodile systems.

Although the major emphasis of these censuses is the monitoring of hippos, other riverine species which may act as ecological indicators are also recorded. These are crocodiles (4 size classes), saddlebilled storks, yellowbilled storks, wollynecked storks, black storks, openbills, fish eagles, goliath herons, grey herons, great white herons, little egrets, whitecrowned plovers, blackwinged stilts, African finfoots. The aims of the study were to monitor population trends and distribution of hippopotamuses in the major rivers of Kruger National Park, to monitor population trends of crocodiles in the rivers of Kruger National Park, and to monitor trends of other riverine species which may act as ecological indicators. In 2004 the Letaba / Olifants system was surveyed. Totals for this census are not yet available due to malfunction of the data digitiser.

## **The current living tuskers of the Kruger National Park**

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There is considerable public interest in these large tuskers in the Kruger National Park. Many of the older ones have now died (Tshokwane, Mandleve, Mlondozi, Shilowa, and Mabarule), but there is a new generation emerging, which requires classification and documentation. Many enquiries are made for information on these animals. The information gained adds considerable interest to visitors and to the displays in the Letaba Elephant Museum. For very little effort, this project serves the interests of SANParks and its visitors. The Phalaborwa Honorary Rangers have taken “ownership” of this project. They handle the day to day running of the project. The current policy with the naming of these big elephant bulls is to give them the Tsonga (or other language) names that were given to Rangers and Field Rangers of the past who gave many years of service to the Kruger National Park. The objectives of the study are, to identify and catalogue the current large tuskers of the Kruger National Park through photographic material submitted by staff and tourists, to gain an idea of these animals’ home ranges through sightings by staff and tourists, and to make the information gained available to tourists through the displays at the Elephant Museum at Letaba. The project was much publicized and as a result, many photographs were received of large tuskers, but no new ones could be added. Sadly, “Mabarule” one of the best-known tuskers of KNP died during this year. He died of old age and examination of the skeletal remains showed that he had severe arthritis, and must have been in considerable pain. Currently the largest bull in KNP is “Duke”.

**Population dynamics and the effects of herbivory and fire on the regeneration ecology of *Acacia nigrescens* and *Dichrostachys cinerea* in the Kruger National Park, South Africa**

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The aim of the present study is to contribute to a better understanding of savanna woodland regeneration dynamics, through an investigation of the effects of herbivory and fire on the population dynamics and regeneration ecology of *Acacia nigrescens* and *Dichrostachys cinerea*. *D. cinerea* is a typical bush encroacher in disturbed habitats (regenerates), whereas *A. nigrescens* is one of the most widespread acacias tolerating a wide range of disturbances and seldom encroaching (persistent). Long-term experiments are set up at the Nkuhlu exclosures. Initial results indicate that not only total annual rainfall, but rather the timing of rainfall events within the season are particularly important in seed production. In 2004 there were good winter rains which resulted in one of the single biggest flowering and seed production events (in terms of both synchronization and total production) in *A. nigrescens* in the park in many years. Large seed production events such as this are thought to be the key to the inputs of seed reserves to the soil.

The effects of fire frequency and intensity (season of burn) on population structure of each species will be investigated at the experimental burn plots (EBP's) at Satara in 2005 and 2006. In particular, the role of bark thickness in determining fire resistance will be investigated in a novel approach utilizing the relationship between bark thickness and trunk circumference at various trunk heights. In addition to this, another objective is added where seedlings will be planted on some of the burn plots and monitored for a few weeks before a fire is put through the plots. Burning of the relevant Satara plots is scheduled for 2006. The survival and growth of seedlings following fires will give invaluable insight into the regeneration of woody species following fire. In particular concerns have been expressed by rangers regarding the encroachment of *D. cinerea* in certain areas. If time and logistics permit, the regrowth of small resprouting individuals will be monitored following destructive burns aimed at reducing encroachment in these areas.

## **Movements and feeding behavior of Epauletted fruit bats and impact on regeneration of Sycomore fig trees**

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Epauletted fruit bats, *Epomophorus wahlbergi* and *Epomophorus crypturus*, were monitored by radiotelemetry in Kruger National Park, South Africa. The study was conducted at Skukuza camp, where bats roosted under thatched roofs inside the camp, and Shingwedzi, where bats roosted in riverine bush. Based on 419 radiotelemetry positions, the mean home range (MAP = 0.95) of five *E. wahlbergi* was 10.3 ha, mean core-use area (MAP = 0.5) was 2.6 ha, and the mean long axis of the home ranges was 744 m. Sample size of *E. crypturus* was unsuitable for statistical analysis of home range and core-use area. Activity hotspots were associated with the common cluster fig tree, *Ficus sycomorus*, a primary food resource of epauletted fruit bats in the dry season in Kruger. Four hundred and nineteen *F. sycomorus* were surveyed and classified according to size and ripeness of fruits, and locations were added to the KNP GIS database. Of those figs surveyed, 35% were fruiting in the Sabie River drainage and 51% were fruiting in the Shingwedzi River drainage.

## **Monitoring the climate in the Kruger National Park**

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In conjunction with the SA Weather Service, routine (daily) monitoring of the climate of the KNP at two 1<sup>st</sup>-order, 6 2<sup>nd</sup>-order and two 3<sup>rd</sup>-order weather stations, and 17 rainfall stations. An automatic weather station was established at Shingwedzi. Data line problems are however being experienced in accessing the station and these will be attended at the earliest opportunity. Approval in principle was given to the SA Weather Service to establish a weather radar in Skukuza. This will be the 13<sup>th</sup> in the country. The necessary EIA and EMP investigations must however still be undertaken.

It was decided to establish two new rainfall monitoring stations at Giryondo border post and Makhadzi picnic site. Being on the Lebombo mountain and on the leeward side respectively, these stations will provide valuable information regarding the rainfall pattern along the Lebombo mountain and immediate vicinity. With the transfer of the Pafuri section ranger to WENELA, the monitoring of rainfall at Pafuri has ceased.

On an overall basis, the KNP received an average total of 393,4 mm during the climatic year July 2004 to June 2005. This is 75% of the long-term average of 537,2 mm and on an overall basis, consequently places the KNP in a drought situation. The north and far north in particular were severely affected, Vlakteplaas having received only 178,5 mm (34,7% of the long-term average for this station). The Shangoni, Shingwedzi and Phalaborwa areas were also severely affected.

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