

KNP 15/1/2 - 08

# **Project Reports 2008**

**Reports on Scientific Research Projects  
undertaken in the savanna parks of the  
South African National Parks  
during 2008**



## Declaration

These reports are edited versions of progress reports received from researchers. They are aimed at giving information regarding the type of research that has been conducted in the Savannah Parks of South African National Parks during 2008. The parks included are, Addo Elephant, Augrabies, Camdeboo, Golden Gate Highlands, Kalahari Gemsbok, Karoo, Kruger, Mapungubwe, Marakele, Mokala, Mountain Zebra, Namaqua, Richtersveld & Tankwa.

Any details regarding individual projects can be requested from individual researcher via e-mail.

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## A REGIONAL SCALE PASSIVE MONITORING STUDY OF SULPHUR DIOXIDE (SO<sub>2</sub>), NITROGEN OXIDES (NO<sub>x</sub>) AND OZONE (O<sub>3</sub>)

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The specific aim of this project was to address a perennial problem, to which there has so far been no satisfactory answer in the Southern African context, namely:

Will the emissions of acidifying trace gases (species of sulphur and nitrogen oxides) from coal burning power plants and industries on the industrial Highveld of Mpumalanga result in accumulated deposition of acidic air pollutants that may eventually exceed the carrying capacity of the natural environment?

To address these quests, a network of 37 passive monitoring sampling sites was established to measure pollutant trace gases SO<sub>2</sub>, NO<sub>2</sub> and ozone. The area covered stretched over the northern and eastern interior of South Africa, excluding the industrial Highveld (except for a reference site near Witbank), while avoiding sources of local emissions such as towns, mines and highways. The sampling field campaign operated from January 2005 to September of 2007. Within this period, the original goal for this project of 24 months of continuous sampling for all three monitored species was achieved. This sampling period enabled accumulating a substantial database of near-surface acidic trace gas concentrations, adequate to inform the major science objectives of the project. The conclusions of this study are that emissions of acidifying trace gases (species of sulphur and nitrogen oxides) from coal burning power plants and industries on the industrial Highveld of Mpumalanga **do not** result in accumulated deposition of acidic air pollutants at levels that may eventually exceed the carrying capacity of the natural environment. Implied by the overall findings are that currently the areas of the KNP and adjacent conservation areas are not under threat of ecological damage from atmospheric acidic deposition.

## LEAF AREA DYNAMICS IN A SEMI-ARID AFRICAN SAVANNA

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This project aims to collect field data on the seasonal patterns of leaf display of the major trees and grasses in two sites in the south of the Kruger National Park. This data is used to validate remotely-sensed phenology data, to derive models for separating remotely sensed data into the main vegetative components (trees and grass), to investigate the environmental cues for leaf display and leaf drop for different species and growth forms in these savanna systems, to produce regional-level phenology models, and to explore inter-annual, inter-site, and inter-species variability in patterns of leaf display. Three years of data has been collected on patterns of green up of the main tree species and the grass layer at the Flux tower site near Skukuza and one year of field data at a site near Pretoriuskop.

This research has given a better understanding of the environmental cues for green up and leaf fall of four major tree species in southern Kruger (Archibald and Scholes 2007). From the results, it appears that *Sclerocarya birrea* (Marula) trees are not cued to flush by temperature or soil moisture, and most likely are controlled by a day-length cue. This means that for Marula, seasonal patterns of leaf display are unlikely to change as temperatures increase. *Combretum apiculatum*, on the other hand has a much more plastic response, largely controlled by soil moisture availability.

## **A SCALED EXPLORATION OF THE DEEP-STRUCTURE OF LANDSCAPES; WAVELET ANALYSIS OF VEGETATION ALONG THE SHINGWEDZI RIVER**

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This project aims at developing an easy to use method for objectively determining the scales at which vegetation patches are distributed across the landscape. The analysis technique allows for an objective analysis of whether or not nested hierarchies are present in the landscape, as predicted by Hierarchical Patch Dynamics. Thus far the analysis technique has been coded, optimized and sensitivity analysis completed. A statistical protocol for the analysis of scale domain position has been developed. Real datasets of alluvial vegetation have been analyzed, indicating the presence of scale breaks at small scales. Computer limitations have prevented the analysis of data with high enough spatial extent to make further inference, but this is being corrected for.

## MOLECULAR DETECTION AND CHARACTERIZATION OF BARTONELLA BACTERIA FROM SOUTH AFRICAN ARTIODACTYLS

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The main objective of this project is to assess the diversity of *Bartonella* species occurring in wild South African artiodactyls in order to increase knowledge and understanding of the prevalence of this bacterial genus. From September 2007 to November 2008, efforts were directed at assessing *Bartonella* prevalence in the African buffalo, *Syncerus caffer* and in four Cetartiodactyl genera, viz. *Giraffa*, *Hippotragus*, *Alcelaphus* and *Redunca*.

Nucleotide sequencing and phylogenetic analysis of the species-informative *gltA* gene revealed the presence of two distinct *Bartonella* lineages in *Syncerus*. In addition to evaluating *Bartonella* in the genus *Syncerus*, bacterial presence in other genera was determined following DNA extraction from 25 EDTA blood samples. These samples correspond to the genera *Giraffa* (N=5), *Hippotragus* (N=10), *Alcelaphus* (N=5) and *Redunca* (N=5). No evidence of *Bartonella* was found in the 5 samples provided for giraffe, hartebeest, sable or roan antelope, each. However, all reedbuck samples screened were found to contain *Bartonella* and nucleotide sequencing revealed the reedbuck bacterial species to be sister to buffalo lineage I, and to have an intermediate phylogenetic placement between the two buffalo lineages (I and II) identified.

## PREVALENCE AND DIVERSITY OF BARTONELLA IN SOUTH AFRICAN CARNIVORES

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The two main objectives of this project were: (i) to assess the *Bartonella* infection rates in large carnivores in the KNP and (ii) to assess the genetic variation of *Bartonella* bacteria present by genetic characterisation and phylogenetic analysis of the citrate synthase (*gltA*) gene. As no additional carnivore samples were received in the period under review, no new results are available for this reporting period. The results of the previous reporting period (January 2007 – August 2007) were however presented in poster format at the South African Genetic Congress held in Pretoria in March 2008.

## GRASS AND TREE WATER-USE IN THE KRUGER NATIONAL PARK

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Explanations for the persistence of tree and grass coexistence in savannas have intrigued ecologists for decades. A form of niche partitioning in which trees access deep soil water and grasses do not has long been assumed to be critical to tree- grass coexistence. The difficulties of belowground research, however, have prevented direct measurements of root activity. The objective of this research was to provide the first direct measurements of water-use throughout the soil profile by trees and grasses. During the first year of our project, we developed and employed a depth-controlled tracer experiment, supplemented by several traditional measurements, to meet this objective. To determine the timing and relative location of water-use by different plant species, we conducted a pulse-chase experiment. To determine the absolute amount of water used by species, we measured soil moisture, transpiration, and leaf area. This combination of techniques produced the first spatially and temporally explicit description of water-use 'niche-space' in a wildland system.

During the first rains of the season (October), both trees and grasses used very shallow (5 cm) soil water with grasses also using water at 20 cm. In the middle of the growing season (November), grasses dominated 5 cm and 50 cm water use and trees and grasses equally shared 20 cm water. During a drought in February, trees stopped absorbing soil water (and relied on water stored in boles), and grasses used deeper soil water than earlier in the season. At the end of the growing season (April), trees continued to rely on 20 cm water and grasses relied on 5 cm water. The results provide a basic understanding of species coexistence in an ecosystem that covers over one-sixth of earth's land surface and supports a growing proportion of human, livestock, and mega-herbivore populations.

## **INDIRECT EFFECTS OF MAMMALIAN HERBIVORES ON INVERTEBRATES IN A RIVER GRADIENT OF THE KRUGER NATIONAL PARK, SOUTH AFRICA**

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The aim of this study was to assess indirect effects of mammalian herbivores on invertebrates in a vegetational gradient towards a river.

Invertebrate specimens were collected in three experimental sites, in three vegetation zones perpendicular to the Sabie River. The field work took place in March 2008, and resulted in information on the invertebrate richness and abundance. The results showed that large and medium-sized herbivores had effects on the invertebrate community, but also that the effects were site specific and different across invertebrate taxa. The river gradient had significant effects on the abundance of Araneae and Coleoptera, and the richness of Araneae and Formicidae. In general, the spider abundance and richness peaked at midrange from the river (in the foot slope). Coleopterans, on the other hand, were more abundant and taxon rich in the riparian zone. In addition to this, the riparian zone housed many ant taxa.

## **TSETSE FLY (GLOSSINA SPP.) SURVEILLANCE IN THE KRUGER NATIONAL PARK**

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The main objective of this surveillance project is to institute an early warning system for detecting and monitoring any re- incursion of Tsetse flies into the Limpopo/Levubu drainage system in the north of the Kruger National Park.

Tsetse fly occurred historically in certain areas of the Kruger National Park up until the Rinderpest pandemic of 1896, when probably due to the decimation of their preferred hosts, the fly disappeared. During the 1960's a tripartite tsetse control programme involving officials from South Africa, Rhodesia and Mozambique succeeded in eradicating tsetse flies south of the Savé River in Mozambique and Rhodesia.

In May, 2008 the annual tsetse survey was again completed in the Limpopo / Levubu drainage. The relatively dry climatic conditions in the northern KNP at that time, resulted in low activity of haematophagous flies. Once again the main genera represented in our catches were several species of *Tabanus*, *Stomoxys calcitrans*, and *Musca spp.* No flies of the genus *Glossina* were detected.

## **A STUDY OF THE BREEDING STATUS, REPRODUCTIVE SUCCESS AND MORTALITY FACTORS OF THE CAPE VULTURE AT THE KRANSBERG COLONY, LIMPOPO PROVINCE**

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The Kransberg colony is the largest breeding site of the Cape Vulture *Gyps coprotheres*, representing approximately 1/3 of the world's breeding population. The "vulnerable" status of the Cape Vulture makes the monitoring of colonies and the identification of the factors negatively affecting this species, an important step in the overall conservation effort necessary to maintain its existence.

The 2007/2008 reproductive season at the Kransberg Cape Vulture colony was the 27<sup>th</sup> year of observations at this location. A total of 738 *occupied* nest sites (where nest building activities occurred and an egg may or may not have been laid) were observed at the colony this year. This was a 5.4% increase in occupied nest sites over the 2006/2007 nesting season (700). Of the 738 occupied nest sites, 697 were *active* nest sites (where an egg was laid). This is a 3.4% increase over the number of active sites during the 2006/2007 breeding season (674).

The number of reproductively active pairs in the 2007/2008 season was the highest in the last 11 years, and was tied for 15<sup>th</sup> highest in the 25 seasons for which complete data are available; however the number of fledglings was the 5<sup>th</sup> highest in that same period. Of *occupied* sites in this season, fledging occurred at 490 (66.4%). This was a statistically higher proportion from the 2006/2007 season when 404 (57.7%) nestlings fledged from 700 *occupied* sites ( $X^2=11.51$ ;  $df = 1$ ;  $p = 0.0007$ ). The proportion of *active* nest sites where successful fledging occurred was significantly different between the 2006/2007 season 404/674 (59.9%) and the 2007/2008 season 490/697 (70.3% -  $X^2=16.21$ ;  $df = 1$ ;  $p = 0.0001$ ). The proportions of young fledged of both occupied and active nests were the highest during this study.

It seems likely that the very dry conditions at the end of 2006 continuing into the winter months (April-August) of 2007 affected the vulture's nesting success rate. Drought conditions were hard on ungulates throughout the country resulting in high mortality and therefore available carcasses for vultures.

## **NATIONAL HERBARIUM (PRE) NATIONAL PLANT COLLECTING PROGRAMME:SANPARKS**

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The aim of the project is to obtain a complete record of the flora of southern Africa (FSA), to record accurate distribution data for all taxa, to record plant biodiversity in a defined area, to record variation in plant species and to obtain a record of plants that flower at times other than at the peak season. The study area will include all SAN Parks, but with the emphasis on those in quarter-degree grids in which less than 300 species have been collected (using PRECIS as main data source). The study will also concentrate on uncollected taxa and on other grids that have experienced events such as very good rains.

Identification of specimens from visits to Karoo, Tankwa, Namaqua and Golden Gate National Parks have mostly been completed. Duplicates of most of these specimens have been sent to KSAN.

**RESPONSE OF SAVANNAS TO FIRE ACROSS A RAINFALL GRADIENT:  
ANALYSIS OF LANDSCAPE PATTERN AND HETEROGENEITY AS PER  
REGISTERED PROJECT**

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This project aims to quantify changes to landscape pattern in medium to high rainfall savannas and link these to rainfall and fire regime (where the highest rainfall sites will be located in Hluhluwe-iMfolozi Park).

## **SURVEY OF THE PEL'S FISHING OWL SCOTOPELIA PELI POPULATION IN THE KRUGER NATIONAL PARK**

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A review of data collected during surveys conducted from 1989-1993 was conducted from records at the Transvaal Museum in Pretoria to use as comparison with findings obtained during the surveys that will be conducted from 2007-2010. Ground surveys of the Luvuvhu- and Olifants rivers in May/June 2007 and 2008 have been conducted and copies of all survey reports as well as processed data of sightings during surveys have been submitted to SANParks. Data of other piscivorous bird species and all raptors were also collected during the ground surveys and have been included in the reports submitted to SANParks. Aerial surveys have been conducted along the Olifants-, Sabie-, Crocodile-, Nwanedzi- and Gudzane rivers during April 2008 to assess the riparian vegetation along these rivers and its suitability as habitat for use by the species. During these surveys, we also plotted all active African Fish Eagle nesting sites and individual sightings of birds to obtain an idea of the distribution and estimated territory size along these rivers. A report and GIS-based maps reflecting our findings have been produced and submitted to SANParks.

In July 2008, the survey of the Olifants river has also been expanded to the APNR and beyond in the Lowveld using volunteers from these reserves and separate reports in this regard have been compiled and are available on request. The Project received some media exposure through a 50/50 insert broadcast on SABC2 on the 24<sup>th</sup> of November 2008.

## **RE-SIGHTING STUDY OF COLOUR-MARKED VULTURES AND OTHER RAPTORS IN THE KRUGER NATIONAL PARK**

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Up to date, 122 Vultures and Marabou Storks (13) have been ringed and tagged at the Moholoholo Rehabilitation Centre since November 2005. In 2008, the only birds to be tagged were two African White-backed Vultures (A121 & A122) who were rehabilitated after poisoning incidents in the Lowveld. The re-sightings database currently amounts to 3953 records of these birds having been re-sighted throughout the Lowveld and particularly in the Kruger National Park. Most of the sightings were made at vulture feeding sites, but at least 700 records have so far been received from members of the public, guides and rangers as a result of our awareness campaign in the area. Re-sightings of vultures tagged in the Lowveld have also been received from KwaZulu-Natal, Swaziland, central Zimbabwe and southern Moçambique. A tagged Marabou Stork has been observed near the breeding colony in Hlane National Park, Swaziland. No mortality records of tagged vultures from the Lowveld have to date been received.

## INTERACTIONS BETWEEN HERBIVORE SIZE AND FIRE REGIME ON PLANT COMMUNITY STRUCTURE

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Humans have simultaneously altered the key biotic and abiotic forces that structure savanna ecosystems by reducing the diversity of native herbivores, removing them completely, or replacing them with domestic livestock, and by altering fire regimes. This can have important implications for ecosystem function as herbivory by a diverse community of mammalian herbivores (primarily ungulates) and fire are both drivers of plant community biomass, plant species diversity, and nutrient cycling. Large herbivores (> 150 kg, e.g. elephant, rhino, giraffe, and buffalo) may serve keystone roles by dramatically altering vegetation structure and by facilitating smaller herbivores, such as impala and bushbuck. However, large herbivores are at much greater risk of extinction and generally are the first to be lost from ecosystems in the face of human encroachment resulting in a herbivore assemblage dominated by smaller animals. Additionally, fire is also an important structuring force for savannas as it reduces encroachment of woody species into grasslands and decreases nitrogen availability. Yet, humans have dramatically altered natural fire regimes in many areas worldwide. Thus, the goal of my research is to quantitatively show how herbivores of different size and fire regime interact as ecological drivers to determine the community structure and ecosystem function of savanna grasslands.

## DIET PATTERNS OF HABITAT USE BY SABLE ANTELOPE, ZEBRA, AND BUFFALO IN NORTHERN KRUGER NATIONAL PARK

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The objective is to determine diet habitat use patterns by sable, buffalo and zebra in the Punda Maria area. Data were collected during 4 daily time periods: night time (2100–0400), morning foraging (0500–1000), midday non-foraging (1100–1500), and evening foraging period (1600–2000). Data collection has been completed in the Punda Maria area, and data analyses are in progress.

Areas used by sable antelope during night time hours had 34%, 23%, 19% lower shrub cover ( $F_{3, 295} = 9.59$ ,  $P < 0.001$ ) than the morning foraging, midday, and evening foraging periods, respectively. Shrub cover within 10 m of zebra locations was highest during the midday period. Shrub cover within 10 m of buffalo followed a similar pattern ( $F_{3, 261} = 3.44$ ,  $P = 0.017$ ).

## **IMPACT OF HUMAN HABITATION ON POPULATION DYNAMICS OF SPOTTED HYENAS**

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The project aims to investigate whether spotted hyenas behave differently around areas of intense human use and habitation across a gradient of human contact. This will enable us to better understand the dynamics of the hyenas and their interaction with humans, as well as the potential for conflict between humans and wildlife, potential resolutions to such conflict, and the zoonotic potential.

Field work has continued with the identification of four new clans in the Lower Sabie, Stols Nek and Malelane sections of the park. Observations have identified the dominant females and to some extent the dominance hierarchies for these clans. Help and cooperation from these section rangers is greatly appreciated. Four radio collars have been put on to hyaenas in the clans close to Skukuza. The remaining radio collars can be put on as soon as a convenient time has been arranged with Veterinary Wildlife Services. Animals that repeatedly use anthropogenic resources at Skukuza and Afsaal picnic site have been identified.

## **LONGITUDINAL STUDIES OF BOVINE TUBERCULOSIS IN THE BUFFALO POPULATION OF THE KRUGER NATIONAL PARK**

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The project aims to continue the longitudinal study on buffalo-BTB interactions. The specific aims are to determine (1) the effects of ecological conditions on BTB prevalence in buffalo, (2) the incidence of BTB as a function of background prevalence, (3) the mortality rate of BTB positive individuals as a function of time since infection, and (4) the temporal and spatial spread of BTB throughout the park. In addition, we are cooperating with further research investigating the relationship between BTB and helminth infection.

To date, we have continued to monitor and relocate our known buffalo. Only 33% of our BTB positive individuals are known to be alive, compared with 56% of BTB negative individuals. However, confirmed deaths have only occurred in 8% and 5% respectively, while we have failed to re-locate the other individuals. The relocations are ongoing.

## HABITAT SUITABILITY ASSESSMENT FOR SABLE ANTELOPE

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We assessed changes in sable distributions in association with sable population declines using location records obtained from (1) park-wide annual aerial surveys (1977–1997), and (2) movements of sable herds remaining in two regions of Kruger Park (2001–2007). Historically, sable have occurred mainly on western granite substrates of the Kruger National Park and areas of core concentrations were evident within their range. Most sable herds were recorded within 0 – 3 km of permanent water sources. However, Kruger National Park has abundant surface water, thus water might not explain sable distribution and habitat selection in Kruger National Park. Although sable, buffalo and zebra were using the same ranges, their correlations were weakly positive. Sable herds were recorded less frequently in blocks with high densities ( $> 7/\text{km}^2$ ) of zebra or high densities ( $>10/\text{km}^2$ ) of buffalo. Wildebeest appeared to show selection for different ranges and/or resources to the sable antelope because the species showed negative associations with sable antelope. Sable has limited spatial options to avoid competitive effects from zebra and buffalo because these two species are widely distributed in the Kruger National Park. Options to spatially avoid these potential competitors are even much less during the dry season when zebra and buffalo widen their ranges to possibly include formerly less preferred habitats.

## ASSESSING PROTECTED AREA EFFECTIVENESS: A META-ANALYSIS OF VERTEBRATE POPULATION TRENDS

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The objective of the project is to measure the ecological performance of Protected Areas (PAs) in terms of the long term persistence of their key biodiversity features. Data have been sourced from published literature, grey literature and online databases. To date my database contains time-series from 540 vertebrate populations of 63 species (mostly large (>5kg) herbivores) from 81 PAs. There has been a decline in population abundance of over 50% between 1970 and 2004. Regional disaggregations of the data show that different regions of Africa have shown highly disparate population abundance trajectories. The robustness of these indexes has been extensively tested by alterations in the methods and sub-setting of the data (such as removing elephants and rhino). These tests show the signals from the indexes are reliable and robust to even large changes in methods. The dataset used here is not a random sample of PAs in Africa; the PAs included are larger and older than the continental average. Much of the data in this study comes from parks with the resources and the skills to carryout long term monitoring programs. There is a positive correlation between PA management capacity and the presence/quality of biological monitoring within a PA. Assuming that increased management capacity means improved mitigation of PA threat processes then the results presented in this paper are conservative; a random sample of PA populations would predictably show a greater decline in populations.

## **TOOTH WEAR AND CEMENTUM ANNULI COUNTS OF AFRICAN BUFFALO FOR AGE DETERMINATION**

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The project aimed to test the hypothesis that tooth root cementum lines provide sufficient discrimination to age buffalo and to assess the relationship between incisor height, molar wear and cementum lines. It was found that even among juvenile buffalo, whose age is presumably known from incisor eruptions patterns, there is a large amount of variability in the number of cementum annuli present. For example, in the 3-4 year old category the number of cementum annuli ranged from one to eleven. Therefore, the data collected suggest that cementum annuli and cementum height are not useful metrics for age determination of African buffalo in the Kruger National Park.

# **A HIERARCHICAL FRAMEWORK FOR THE ANALYSIS OF SAVANNAS AS WATER-CONTROLLED ECOSYSTEMS, APPLIED TO THE LANDSCAPES OF KRUGER NATIONAL PARK**

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The aim of this project is to describe the spatial organisation of savanna landscapes in Kruger National Park in terms of patterns constrained both by the configuration of drainage networks and a hierarchy of interdependent soil, vegetation and hydrological systems.

The conceptual framework that will inform the classification has been outlined, but is subject to revision as the classification proceeds. The classification depends on the marriage of DEM-derived topographical characteristics of the drainage network and vegetation classification from remotely sensed imagery. So far, the following has been conducted, delineation of streams and their catchments, nested by stream order, deriving network metrics such as Horton ratios, flow lengths, area drained, stream density, basin shape etc.; used these metrics to produce a provisional classification of geological/climatic units and explored options for the delineation of vegetation and soil from the different sets of remotely sensed imagery that are currently available.

## ECOLOGY OF ANTHRAX IN THE KRUGER NATIONAL PARK

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The object of the project is to ascertain the effect of the last major flood on the anthrax spore count.

A specialized and dedicated anthrax diagnostic facility has been established during the year at the Regional State Veterinary Laboratory at Skukuza. This diagnostic facility can now provide reliable and a fast diagnosis through expert analysis of blood smears, backed up by isolation and biochemical procedures. This will also provide the necessary facilities for further research on anthrax. Pafuri was visited during May 2008 to do the annual collection of soil samples from the Hape permanent plots. The object is to ascertain the role of soil during the dormant phase of the *Bacillus anthracis* organism and to determine the effect of major floods on the soil anthrax spore count. This can throw further light on the “concentrator area” hypothesis and have predictive value for outbreaks. The 2007/2008 anthrax outbreak in the Northern Cape, the home of Mokala National Park, with the Richtersveld and Kalahari Gemsbok National Parks nearby, provided an ideal opportunity to study the epidemiology of anthrax in the region. It also provided the opportunity to compare it with findings in the Kruger Park. The findings were presented as presentations at the SASVEPM Congress and Kimberley Information Session (*vide infra*) and will be published in due course.

## **SURVEY OF ARACHNIDA OF THE KRUGER NATIONAL PARK WITH EMPHASIS ON SPIDERS (EXCLUDING MITES AND TICKS)**

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The aim of the project is to collect, describe and make an inventory of the Arachnida species of the Kruger National Park. Since the publication of the first checklist of the spiders of the KNP in 2003 when 152 spider species from 40 families were recorded, several additional surveys have been undertaken and the database now totals 850 records. Presently 13.8% of South African spider species are protected in the Kruger National Park. Several scorpions have been collected but still need to be identified. A new study (University of Pretoria) is underway in the park on the effect of fire regimes on spiders. Part of the survey of the project have been completed but the material still needs to be sorted and identified. An annotated checklist for the spiders to include all the new KNP species is in preparation. The first checklist of the Pseudoscorpions of the KNP is also planned.

**ESTABLISHING A GROUNDWATER REFERENCE MONITORING NETWORK  
IN THE KRUGER NATIONAL PARK: MONITORING THE RESPONSE OF  
GROUNDWATER LEVELS UNDER UNIMPACTED CONDITIONS TO  
DETERMINE SHORT, MEDIUM AND LONG TERM TRENDS IN  
GROUNDWATER LEVELS AND TO ESTIMATE TPC LEVELS FOR  
ABSTRACTION BOREHOLES**

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The objective of the project was to monitor the response of groundwater levels under unimpacted conditions and to determine seasonal and long term trends in comparison with rainfall; contribution of groundwater to base flow during dry winter periods; comparison of water level behavior in the different surface water catchment areas or lithologies (geohydrological units) and subsequently to optimize and determine the most effective monitoring station density.

To date 34 unused boreholes have been equipped with electronic data loggers. Although a reasonable coverage of monitoring boreholes was achieved only existing boreholes could be used for this purpose. This resulted in some gaps in the network where initial selected boreholes were either still in use or were damaged or where no boreholes were available. Another problem experienced was that a number of the data loggers packed up resulting in data losses. This was only discovered during the first download in May 2008. Some loggers were replaced in May 2008 and the rest only during the second download in November 2008. Despite this setback good data was obtained from the rest of the loggers.

## 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 one of the most economically important viral diseases of animals and is recognised as a significant constraint to international trade in animals and animal products. The outbreaks of FMD since 2000 both in the disease free zone and the buffer zone of South Africa indicated the devastating effects it could have on agricultural production and loss of export markets for agricultural products. 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 spread of the virus to adjacent domestic animal populations. It is established that buffaloes (*Syncerus caffer*) in southern Africa maintain the SAT types of FMD virus but precisely how they are maintained within free-living buffalo populations and the mechanisms by which they can transmit virus to domestic stock are not clearly understood. Impala are considered 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 genetic 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.

## CONSERVATION GENETICS OF THE SOUTH AFRICAN WILD DOG METAPOPOPULATION

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This project aims to obtain baseline genetic data on South Africa's Wild Dog metapopulation in order to provide a basis for sound population management to reduce inbreeding and maintain levels of genetic heterozygosity similar to those found in large free-ranging populations. A key component of the project is to assess metapopulation genetic data within the larger scale variability of southern African Wild Dog populations. The Kruger National Park (KNP) is the only place in South Africa which has a self-sustaining and viable population of wild dogs, and has been an important source of founding individuals for several of the metapopulation reserves. Thus by understanding the genetics of the Kruger Wild Dogs an assessment of changes in genetic structure within KNP over time can be made and a benchmark will be provided by which to compare and base the metapopulation genetic structure.

This report covers the period from September to November 2007. Ten packs of wild dogs were identified and 84 individuals were acknowledged in total. Genetic material was collected from seven of the 10 Wild Dogs packs (70%), thirty two samples were collected from individuals.

The total number of Wild Dogs in southern KNP was higher in 2007 than 2005 even though the same number of packs was found in 2005 (Table 3). This is a good indicator that the number of Wild Dogs in South and Central Kruger has increased over the last two years, especially as the whole of the Central Kruger was not examined during the three months of observation in 2007.

## HERBIVORY ON WOODY PLANTS AND INDUCED RESPONSES IN TWO SIMILAR SPECIES OF ACACIA IN THE KRUGER NATIONAL PARK, SOUTH AFRICA

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I studied browsing patterns and the effects of browsing by different groups of herbivores on woody plants in Kruger National Park in South Africa. I determined how the browsing pressure varied with distance to water and measured inducible responses on two species of Acacia (*A. exuvialis* and *A. grandicornuta*). Results show that browsing was greater on footslope than on crest, and greater where all herbivores had access to the plants compared to where elephants and giraffes were excluded. Effects of elephant exclusion were greater on crest than on footslope. Some evidence of inducibility of plant responses was found. Spines were 39 % shorter in FE compared to NE for *A. exuvialis*, but leaf lengths seemed to increase with exclusion of herbivores. A strong positive correlation was found between shoot length and spine abundance, but because of heavy rain near the end of fieldwork, shoot lengths and spine abundances were greatest in PE.

The effects of elephants on the woody plants of the savanna ecosystem demonstrated in this study are alarming when considering the rapidly growing populations of elephants and the potential damage they can cause. The greater effect of elephant exclusion I found on the crest is a result which would be interesting to incorporate into elephant management. Long spines and short leaves make plants less attractive to mammalian herbivores and this is very important to consider in the widespread and growing utilization of savanna vegetation as food for livestock, because if the sizes of elephant populations continue to increase, the competition between wildlife and livestock for the savanna ecosystem will do the same.

## INVESTIGATING SPATIAL HETEROGENEITY AND RESILIENCE USING PIOSPHERES

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Preliminary analysis of field data and investigation of waterpoint patterns revealed that using the piosphere approach in the southern African savanna may be restrictive. The piosphere approach was developed in Australia in single herbivore species systems. Study areas were selected for homogeneity of vegetation. The southern African savanna is heterogeneous with a wide range of mosaics at different scales.

A detailed investigation of the development of the piosphere approach and its modern usage reveals other studies which have struggled with application in heterogeneous areas. Studies in favour of using the piosphere approach are performed either in homogeneous landscapes or in portions of heterogeneous landscapes which are selected for homogeneity. At management scales in the southern African savanna, the piosphere approach is invalid as the degree of heterogeneity is too high. There is therefore a need to develop an alternative way to understand the impact of artificial water supplementation across a landscape.

This study is currently working on developing an alternative understanding of the impacts of artificial water provision across a landscape (the management unit scale). Field data is being analysed to show that there is a lack of general piosphere pattern at broad scales between waterpoint types (artificial and natural) and artificial waterpoint positions (crest and lower slopes). Field data will then be combined with GIS layers in order to gain a better understanding about factors influencing herbivore utilization of the landscape at broader scales.

## 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. The basic hypothesis is that the hydrogen isotope ratio (<sup>2</sup>H/H ratio) of the water available to both grasses and trees at both sites will change with soil depth. Surface soil water is isotopically enriched in the heavier isotopes of hydrogen (<sup>2</sup>H) and oxygen (<sup>18</sup>O) because of fractionation due to evaporation. The deeper the source of the water the more negative the isotope value is, those plants sourcing water at the surface will reflect a more enriched isotope signature than those plants sourcing deeper water (Thorburn and Walker 1993). Mean  $\delta^2\text{H}$  values for the three size classes from our 2003 sample are Small -6.86‰, Medium -10.58‰, and Large -15.2‰ a T-Test shows that the results for the small and big trees are significantly different ( $P < 0.001$ ) with the values for the bigger trees being more negative indicating the use of deeper water. The suggestion is that there is competition for water between trees and grasses at Pretoriuskop. This competition is however only at the establishment stage when trees are rooting in the same soil horizon as grasses. Once trees have matured our data suggests that there is no longer competition for water with grasses as these larger trees are using a deeper water source.

Grass growth is stimulated by increases in available water. With that increase in grass growth there is more competition for resources leading to a decline in tree growth rates. The increase in grasses also leads to an increase in grass biomass which results in increases in fire intensity and thus a decline in tree dominance. The results of more than four decades of fire manipulation presented here show that fire frequency, fire season and total fire exclusion do not influence the size of tree populations. This finding was consistent across four different savanna sites ranging from moist (737 mm p.a.) to semi-arid (447 mm p.a.) and from nutrient poor granitic soils to nutrient rich basaltic soils.

## THE SPATIAL DYNAMICS OF WILDLIFE POPULATIONS ACROSS AND ALONG THE NORTH-WESTERN KRUGER NATIONAL PARK BOUNDARY FENCE, SOUTH AFRICA

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Management of the fences are severely constrained not only by limited budgets (ZAR 5 million annually for KNP), but by a limited understanding of the ecosystem processes (e.g. the distribution of seasonal surface water inside and outside of the park) and behavioural drivers (why are male elephants more likely to leave the park ?) underpinning fence breakage frequencies. Some sections of cross-border fences have been removed to allow wildlife movement and biodiversity re-wilding (fences can create biodiversity gradients), but without providing any disease risk assessment prior to fence removal. In other sectors of the network (e.g. Limpopo National Park), new fences have been proposed in order to keep wildlife in and human settlers out. Mitigation of these problems requires the identification of the most appropriate integrated strategies for managing and monitoring fence systems within the entire transfrontier network. We believe that a transfrontier fences management plan coupled with a robust and harmonised fence monitoring regime will allow management to efficiently enact interface solutions. This project aims to address these operational and policy needs by assisting in the development of a such a plan thus enhancing fence interface management and providing a model for other fenced protected areas in Africa.

## LARGE HERBIVORE POPULATION REGULATION IN THE KRUGER NATIONAL PARK

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Management of constrained populations requires an understanding of the processes that result in population change as well as how the abundance of a particular species may be limited. Density dependent and independent factors are often assumed to regulate herbivores, however, often in testing the relative importance of these two factors, appropriate null models are not considered. We used annual aerial counts of 14 herbivore species relatively common in Kruger National Park (KNP) to investigate the relative influences that density dependent and density independent (rainfall) factors have on population dynamics. We compared the evidence for density dependence and independence from an appropriate null model. We found that there was no evidence for density dependent change in population growth. Rather the herbivore populations in KNP appear to be represented best by a random walk model of population change. Using African buffalo as an example, we illustrate that we can predict through Monte Carlo simulation when populations would fall outside any upper and lower acceptable limits specified by KNP managers across a range of abundances. Further, we discuss the importance of including appropriate null models of population change when drawing inferences from multi-model comparisons and the resulting weight of evidence that arises from multiple statistical tests for density dependence.

## **CHEMICAL IMMOBILIZATION OF HYENA WITH MEDETOMIDINE, BUTORPHANOL, MIDAZOLAM COMBINATION, WITH FULL REVERSAL**

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Numerous drug combinations have been used to immobilize Hyena of which all have their own drawbacks, such as stormy induction and recovery times and hyper salivation. In this project we used a combination of medetomidine, butorphanol, midazolam to immobilize a hyena for a period of 30-40 minutes. The great benefit of this combination is that it is fully reversible with flumazenil, naltrexone and atipamezole. Overall the project was an excellent success with Hyena. This combination allowed for a fast induction 3-5 min, great oxygen saturations and fast recovery times (M=8 min). In addition if the animal is to be released into a new area or a boma the midazolam does not have to be reversed providing for some post immobilization sedation. This combination can then be used for short field procedures of less than 50 min, if using the reversal drugs, or for longer translocations without reversing the drug combination. Once immobilized the hyena was intubated and end-tidal CO<sub>2</sub>, blood pressure, arterial blood gas, and vital signs were recorded for 30 min then the hyena was reversed (woken up). This drug combination provided a safer more effective immobilizing drug combination for Hyena than previous combinations. In fact one of the study hyena's had two snares, one around his neck and one around a foot, that were removed during the project. This animal was immobilized three times over nine days and was then released back into the park and was seen with his clan the next night. A total of 22 hyena immobilizations were completed along with TB testing and 5 collars placed on 3 different clans. No injuries to animals or staff occurred, and on numerous occasions immobilized hyena were seen the next evening after being released.

## **ANALYSIS OF THE SPATIAL PATTERNS OF LARGE HERBIVORES POPULATION DYNAMICS IN KRUGER NATIONAL PARK**

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The project aimed at better understanding the declines observed in large herbivore populations during the 80s in Kruger NP by investigating spatial distribution changes of the 11 large herbivore species for which trend analysis has been conducted in Ogutu & Owen-Smith 2003 (Eland, Giraffe, Impala, Kudu, Roan, Sable, Tsessebe, Warthog, Waterbuck, Wildebeest, Zebra). We used standardized principal component analyses (sPCA) to investigate distribution changes.

Results suggest that a spatial redistribution of herbivores occurred before the abundance declines actually started. This may have implications in terms of monitoring populations, as detecting continuous changes in distribution may be seen as a early warning signal for deeper investigation of ecological processes taking place. However, because we did not find relevant similarity between species in the spatial changes observed, and did not find also ecological variables which may have explained the observed changes, it is difficult to suggest any further implications.

## **ASSESSMENT OF LION POPULATION DEMOGRAPHY AND ABUNDANCE IN THE KRUGER NATIONAL PARK: IS BOVINE TUBERCULOSIS HAVING AN EFFECT?**

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This project aimed to develop a technique that can be used by managers and researchers of lion populations to determine population estimates and population processes. Firstly, our results do not justify total laissez-faire approaches to the detection of new exotic diseases in a National Park. However, our results reflect on the historic consequences of actions that allowed disease spread – a consequence that lion managers have to deal with now. At least in Kruger the persistence of lions is not threatened, however, these dynamics could change in different climatic conditions. We thus propose that monitoring is essential, and now have a technique that allows relatively efficient monitoring of not just densities, but aspects of demography. However, we concede that complementary focal monitoring directed at estimating fecundity independently could further enhance evaluating the consequences of any external influence on lion population persistence. We advocate such combined approaches since it allows not only evaluation of past events, but also prediction of future changes.

## TRIGGER AND REGULATORY MECHANISMS OF MUSTH IN AFRICAN ELEPHANTS

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The overall aim of the study is to identify possible triggers and regulatory mechanisms of musth by describing physiological, physical and behavioural musth related changes and how these influence the use of ecological and social resources by free-ranging male African elephants during musth and non-musth. The main study is currently conducted on six adult elephant bulls, which were collared by *Kruger National Park* (KNP) in collaboration with the *Transboundary Elephant Research Programme* in December 2006 in the northern part of KNP. The collared elephants were closely monitored for 13 months (June 2007 – June 2008) in an area of approximately 5,500 km<sup>2</sup>.

In total 2321 hours (on 621 occasions on 318 days) were spent in the field to find and observe the focal animals. Furthermore, 29 hours of sound recordings have been made, and 546 faecal and 177 urine samples have been collected. The measurement of immunoreactive steroids and other clinical parameters in the collected samples, as well as the analysis of acoustic records and behavioural observations are conducted from July 2008 onwards until the end of the project. The revealed data sets will be statistically evaluated, and the results presented on national and international conferences and published in peer-reviewed journals and final reports.

## LONGITUDINAL STUDIES OF BOVINE TUBERCULOSIS IN THE BUFFALO POPULATION OF THE KRUGER NATIONAL PARK, SOUTH AFRICA

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To use a combination of mathematical modeling and fieldwork to better understand the dynamics of BTB in the buffalo population. Mathematical models that are intended to aid in management decisions must have a firm foundation in empirical data. Otherwise, it may be unclear whether the model actually captures the important processes of the system or just fits the current data. There are several model parameters for the buffalo/BTB model that have not been estimated in the field. We estimated these parameters through field observations and repeated testing buffalo in six focal herds. These parameters were then used to construct mathematical models of the BTB/buffalo system, which were then used to address management questions. Radio-tracking data indicated that all sex and age categories move between mixed herds, and males over eight years old had higher mortality and dispersal rates than any other sex or age category. In part due to the high dispersal rates of buffalo, sensitivity analyses indicate that disease prevalence in the background population accounts for the most variability in the BTB prevalence and quasi-eradication within the focal herd. Vaccination rate and the transmission coefficient were the second and third most important parameters of the sensitivity analyses. Further analyses of the model without dispersal suggest that the amount of vaccination necessary for quasi-eradication (*i.e.* prevalence < 5%) depends upon the duration that a vaccine grants protection. Vaccination programs are more efficient (*i.e.* fewer wasted doses) when they focus on younger individuals. However, even with a lifelong vaccine and a closed population, the model suggests that >70% of the calf population would have to be vaccinated every year to reduce the prevalence to less than 1%. If the half-life of the vaccine is less than five years, even vaccinating every calf for 50 years may not eradicate BTB. Thus, although vaccination provides a means of controlling BTB prevalence it should be combined with other control measures if eradication is the objective.

## **FIRE HISTORY AND LONG TERM VEGETATION DYNAMICS IN SOUTHEASTERN KRUGER NATIONAL PARK**

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The project utilises palaeoecological techniques like fossil pollen, charcoal and stable isotope analysis to study vegetation change over time-scales of hundreds to thousands of years. The aim is to study patterns of variability in savanna vegetation, exploring the role of climate, fire and disturbance in ecosystem dynamics. The understanding of the long term influence of socio-natural interactions in the shaping of the landscape is of importance for the maintenance of the park ecosystem today. Gillson and Ekblom are working on long-term palaeo records (pollen, isotopes, diatoms and charcoal from throughout the park, while Dr Ekblom has also taken a specific focusing on Fire history and long term vegetation dynamics in eastern Kruger National park and Limpopo Park. She has sampled in Mozambique as part of this project. The paleoecological studies of these sites will enable a comparison of vegetation patterns and its linkages to the differences in management practices on either side of the Kruger Park and Limpopo park over long term and particularly during the last century. Kristina Duffin has completed work on pollen landscape modelling, and calibration of the charcoal record, while Elinor Breman is working outside of the KNP in the savanna grassland ecotone to the west, aiming to identify transitions between savanna and grassland in the palaeo-record and explore the factors driving these changes.

## **DETECTION OF BABESIA AND THEILERIA PARASITES IN WHITE RHINOCEROSSES (CERATOTHERIUM SIMUM) IN THE KRUGER NATIONAL PARK, AND THEIR RELATION TO ANAEMIA**

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The objectives of this study were to detect the presence of *Babesia* and *Theileria* parasites in blood of white rhinoceroses in the Kruger National Park using RLB and to evaluate whether these *Babesia* and *Theileria* parasites, when present, are pathogenic to their host (as manifest by anemia developing). Out of the 195 samples tested, no animals tested positive for *Babesia bicornis* using the RLB hybridization assay. A prevalence of 36.41% for *T. bicornis* was seen in the population. There was no significant change to the blood picture with this infection, i.e. no significant change in haematocrit, RBCs, MCV, MCH, MCHC or PLTs. There was, however, a slight increase in WBC count in those animals infected. There was no significant difference between seasons or between age and sex classes. However, when one takes a look at the age/sex spread of infection rates in table 1, the sub-adult female proportion of the population is significantly more affected than the rest of the population. There was also an unexpected 9% prevalence of *Theileria equi* in the study population.

Although, this study confirms a relatively high prevalence of *T. bicornis* in the white rhinoceros population in the KNP, it also showed that the parasite did not seem to cause any ill health to the animals concerned. It seems to represent another instance of an endemically stable situation, where co-evolution of parasite and host has been pushed to the degree that clinical disease is no longer a factor

## **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. Biggs & Potgieter 1999 briefly summaries this history and point to further references. 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.

## 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 (*C. arabicus*) and cuckoo (*C. galili*) and seed predator (*S. sycomori*) 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.

## TREE PATTERNING AS A RESULT OF FIRE FREQUENCY

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In this paper, we investigate which factors determine tree clustering in Southern African savannas. This was tested by measuring clustering of trees using the T-squared sampling method in plots of the Kruger National Park experimental burning programme in South Africa. Fire return interval is the main treatment in these plots, but also several auxiliary determining parameters like clay content in the soil, diameter of tree canopies, understorey composition, tree species diversity and average annual rainfall were measured while sampling. In the Kruger National Park 48 plots distributed over four different landscape types and with three different burning treatments (never, once every 3 y and annually) were sampled. First, we related the clustering of trees to these environmental variables. When looking at the most abundant species in each plot, the analysis revealed that clustering is mainly correlated with clay content in the soil. This analysis also showed that fire frequency had a positive effect on the clustering of tree species that are not very abundant. We suggest that less abundant species might be less resistant to fire and therefore adopt a mechanism of clustering to exclude grass fires under their canopy. Finally, we tested the effect of clustering on the impact of fire on trees by analysing the relationship between the distance of a tree to its nearest neighbour and its canopy diameter. We found that clustering reduces the damaging effect of fire on trees. Our study contributes to understanding of savanna functioning by showing which processes are relevant in the distribution of savanna trees.

## **DEVELOPING AN IMPROVED CYBERTRACKER INTERFACE THROUGH PARTICIPATORY DESIGN FOR MANAGING HUMAN RESOURCES AND BIODIVERSITY DATA IN NATURE CONSERVATION**

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This project set out to assess the impact of the existing Cyber-Tracker interface and approach in the adoption of the software in South African National Parks. Users of the CyberTracker system as a whole were discovered to fall into 4 distinct groups of users (1) Field rangers using the handheld units (2) Section rangers downloading, querying and viewing data (3) Scientific services and specific projects which design sequences for handhelds (4) management which require reports and use information for decision making or analysis. The current CyberTracker interface incorporates functionality for all these groups (with the exception of the field rangers) into a single interface. As a result section rangers who are primarily concerned with querying data need to (a) have an understanding of the sequence design and (b) are hindered by more advanced and superfluous features in the interface. Section rangers make use of approximately 15 – 20% of the total functionality the interface offers. This results in the interface being overwhelming and cluttered for a good number of users. While most section rangers were able to perform simple querying tasks with the existing interfaces, more advanced queries were difficult to produce for section rangers.

Kruger Park would benefit from instituting a redesign of the CyberTracker interface with the objective of streamlining the functionality for the various user groups. Creating a more user-friendly interface would promote the use of the system among section rangers. A simpler interface with radically reduced functionality would also reduce the time needed to learn how to use the system effectively. This in turn would reduce the time taken on daily queries.

## REGENERATION ECOLOGY, ADAPTIVE RESPONSES AND GROWTH RATES OF MARULA IN SOUTHERN AFRICA

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The main objective of the project being conducted in the Kruger National Park is to determine above ground relative growth rates of *Sclerocarya birrea* subsp. *caffra* (with special emphasis on the missing size class (trees from 2-8 m in height)) and relate these relative growth rates to variation in spatial and temporal contexts by comparing between sites with different conditions and between years of measurement. Marulas have been marked in the roan enclosure near Shingwedzi and in the Hlangwine enclosure near Pretoriuskop where this size class occurs. This monitoring is ongoing and the field work for the first year of monitoring was conducted in November 2008, hence no findings can be reported on to date. However preliminary observations indicate that the growth rate is in the range of 1 mm of diameter increase per annum and a large proportion of the population is actually showing negative growth thought to be due to the effect of the utilization of resources to recover from fire topkill. Trees in the Hlangwine enclosure in the Pretoriuskop area are growing much faster than those in the Roan enclosure near Shingwedzi. Differences in the growth rates of the different size classes have not yet been examined. In addition to the main objective described above other life history factors of marula are being investigated in the KNP. A resurvey of trees marked in 2001 has revealed a mortality rate of 2% per annum in the southern part of the KNP. Levels of utilisation of these trees have tripled since 2001. Further surveys of the marula population have been conducted to supplement previous studies. These surveys have collected data on utilization levels, mortality and population composition. This information will be used to formulate a predictive model for the future persistence of the marula population in the areas studied. The reaction of marked marulas to fire have also been investigated. Approximately 45 trees 2-3m in height have been marked and followed since November 2007 in the Pretoriuskop area. These trees were burnt in September 2007. Preliminary findings indicate that even though resprouting may be occurring in the canopy after topkill in this size class, one year after the fire, approximately 20% of these individuals are targeted by browsers and reduced to resprouting from the root crown in effect losing 100% of their height. This is interesting as it appears that directly after the fire height loss is not as extreme, while as time passes this size class is reduced to a seedling height. Since this project mainly entails long term monitoring of marked trees, detailed results on growth rates will only be presentable once the last monitoring session has been conducted.

## **POPULATION DYNAMICS AND ELEPHANT MOVEMENTS WITHIN THE ASSOCIATED PRIVATE NATURE RESERVES ADJOINING THE KRUGER NATIONAL PARK**

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One of our prime objectives is to understand what motivates elephants to move across boundaries, hence our name, the Transboundary Elephant Research Programme. We are studying the safety, social and nutritional motivating forces behind elephant movements to the east, west and north of core conservation areas such as the KNP. We specialise in tracking elephants using either GPS satellite or GMS/GPS radio collars. We identify individual elephants, study population dynamics and habitat use, and examine the effects of elephants on key tree species. A total of 2 918 sightings of bulls have been made between May 2003 and August 2008.

A total of 888 sightings of breeding herds were made since May 2003 until August 2008. This figure includes multiple sightings of the same herd within a month as well as sightings of herds where no identification records could be collected either due to poor visibility or rapid movement amongst the members of the herd. A total of 292 identikits of cows within family units have been collected.

## BUTTERFLY SURVEYS IN THE RICHTERSVELD NATIONAL PARK

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The numbers of butterflies were very limited, especially in the north above Rooiberg and Mt Dixon as this area was still very dry awaiting the summer rains. The southern areas were full of flowering plants, however these did not attract the butterflies that seemed more intent on traveling. The *Aloeides barklyi* were concentrated in a small area on the slopes of the base of Akkadis Pass and are very localised species. We were unable to establish their larval foodplant as the females were more intent on nectaring than laying. *Blepharis sp* (Acantheae), foodplant of *Alenia namaqua* was also found in abundance on the roadsides of Akkadis Pass with the seemingly the core population of *Alenia namaqua* being at the top of the pass. *Brephidium metophis* (Tingtinkie Blue) although scarce, were also found scattered among the *Blepharis* flowers and were easily mistaken for the more abundant *Alenia namaq*. *Chrysoritis chrysaor* (Burnished opal) was found in a drainage ditch at the Halfmens forest opposite the Hand of God, nectaring on some unrecognized small white flowers. They only numbered about 6 specimens that quickly disappeared after being disturbed by us. The *Aloeides damarensis* were also very scarce and found in the flatter sandy patches where there were still some dried grasses at the bottom of Akkadis pass.

Interesting species found were *Colotis doubledayi flavulus* (new localities), *Aloeides barklyi* (extension of the range), *Chrysoritis chrysanthes* and *Alenia namaqua*. The best records were two *Colotis celimene pholoe* which had not been collected in that part of the country before. There are now four recorded specimens of *Colotis celimene pholoe* from South Africa, the two from the Richtersveld National Park and two from the Tswalu Kalahari Nature reserve near Hotazel, which is about 600km east of the Richtersveld. Graham Henning and Keith Roos have collected one specimen at each locality of *Colotis celimene pholoe*.

## BIOLOGICAL CONTROL OF OPUNTIA STRICTA IN KRUGER NATIONAL PARK

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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 biomass of *O. stricta* has declined by over 90% and remains low. There has been almost no fruit production on the plants for the last three years due to the insect damage not allowing the plants to reach a reproductive size (>27 cladodes). This suppression of fruiting has stopped long-range dispersal of the weed and so there is no threat of the weed appearing in uninvaded areas.

## INFLUENCES OF TOPOGRAPHY AND LARGE HERBIVORES ON SOIL RESPIRATION IN A GRANITIC SAVANNA

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Soil respiration (sum of root respiration and microbial respiration) is an important component of ecosystem respiration and represents a major flux of C to the atmosphere. However, the relative importance of the factors for controlling soil respiration is not well known in semiarid savannas, with a dearth of information on the African continent. We utilized the Nkuhlu and Letaba large animal exclosures; in 2007 we established several transects along the catena inside the exclosure and in an adjoining reference area. Soil respiration rates were measured seasonally using a LI-8100 Infrared Gas Analyzer (see picture). In order to establish the influence of savanna trees on soil respiration, we measured soil respiration under trees as well as in open areas in each of the landscape positions inside and outside the large animal exclosures. At the same time soil temperature and volumetric soil moisture levels were measured.

Our results for the dry (winter) and wet (summer) season show that soil respiration rates are significantly higher in riparian zones than in upland areas. In addition, savanna trees are influential in that soil respiration rates were significantly higher under trees than in open areas. Though it is clear that herbivory by large herbivores reduced aboveground herbaceous vegetation biomass, and also lead to increased soil bulk density, no significant influence on soil respiration could be detected in these preliminary results. Further analyses showed that soil moisture is more influential in controlling soil respiration rates than soil temperature. This is also evident in the positive relationship between topography and soil respiration, with riparian zones wetter than uplands and also showing higher soil respiration rates. We can conclude that soil temperature seems to be less important in determining soil respiration rates in semiarid South African savanna, perhaps due to the relatively high mean monthly temperature, even in winter (see also Mantlana 2008). Further, riparian zones, despite occupying a small part of the landscape, seem to be a hotspot for soil respiration, similar to other soil processes such as N mineralization and denitrification.

## **AN INVESTIGATION OF THE EFFECT OF FIRE FREQUENCY ON SOIL CARBON FRACTIONS ACROSS A RAINFALL GRADIENT**

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The study aimed to assess the effect of burning on soil carbon fractions. Soil samples, as well as fire and climatic data available from the Kruger National Park (KNP), South Africa and Kavango, Namibia were used.

Organic carbon and nitrogen levels were found to be unaffected by rainfall. Since fuel load is proportional to rainfall as grass biomass accumulates with increasing rainfall and post fire age, we would expect sites with higher rainfall and corresponding fuel load/biomass to show a higher percentage of soil organic carbon across all treatments. However, in this study, no difference in soil organic carbon levels was found between sites with varying rainfalls.

In the KNP, burning was found to decrease the percentage of organic carbon in the soil, but not as a function of frequency. We would expect unburned sites to have substantially more carbon than burned sites, as low frequency burning generally results in a higher percentage of carbon than sites burned at a high frequency. The control plots did however contain a higher percentage of carbon than the burned plots, which leads us to conclude that the effect of burning is related more to 'total exclusion of fire versus the occurrence of fire' than to actual fire frequency.

## **DEVELOPMENT OF A DECISION MODEL FOR ASSESSING THE DYNAMICS OF FOOT AND MOUTH DISEASE (FMD) AND AFRICAN SWINE FEVER IN THE GREAT LIMPOPO TRANSFRONTIER CONSERVATION AREA (GLTFCA)**

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Wildlife diseases are common within national parks. In that context, Transfrontier Conservation Areas (TFCA's) increase interactions between different components at the human-livestock-wildlife interface and require accurate management of diseases. The spread of disease within the wildlife populations in TFCA's could have disastrous consequences for ecotourism in the region. In addition, the spread of disease from wildlife to domestic herds will impact on food security in the region and should be minimized. To tackle that issue, a consortium of international research institutions and the TFCA Veterinary Programme at the University of Pretoria have the goal to develop a stochastic decision/risk assessment model to assess the risks and impact of selected diseases within the TFCA and the possible knock on effects of these diseases. The selected region is the Great Limpopo Transfrontier Conservation Area (GLTFCA) where diseases of major economic importance involving wildlife host such as Foot and Mouth Disease (FMD).

Quantifying the risks associated with spread of diseases within TFCA,s can be a useful tool to predict the occurrence of outbreaks and their possible impact to TFCA buffer areas allowing to target control or preventive measures. It can also assist in policy decisions for formulating cost effective control strategies of interest for park managers, conservationists and animal health authorities and will also point out to decision makers the areas where deficiencies in data exist, allowing to form a platform for further research on selected topics in disease investigation. In order to address this ambitious goal, it was decided to start with the development of qualitative risk assessment framework in order to assess the current risk of FMD occurrence in the Western boundary of the KNP. Indeed, since the year 2000 at least five declared outbreaks of FMD have occurred in the area adjacent to the KNP, despite the implementation of control measures. Although only one of these outbreaks threatened the free zone, it was found necessary to develop decision tools in order to help in the implementation of efficient disease control strategies.

## THE ROLE OF HOST GENETICS IN SUSCEPTIBILITY TO ANTHRAX AMONG BURCHELL'S ZEBRA (*EQUUS QUAGGA*) OF SOUTHERN AFRICA

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Infectious disease is a major driver of ecological dynamics in natural systems, molding the histories of populations and species. Pathogens, capable of rapid evolution, are a primary selective force directly challenging host fitness. At the same time, hosts have evolved a diversity of adaptive and innate defenses in response to these challenges. There has been growing evidence that the constant co-evolutionary interaction between hosts and pathogens promotes genetic diversity, through both positive and balancing selection, in functional immune-related genes. Genetic diversity may be particularly important in the Major Histocompatibility Complex (MHC), a family of immune genes known to modulate a host's resistance to parasites and pathogens. Also, disease-specific candidate genes, with known functional roles in disease pathogenesis, will provide invaluable information for advancements in disease ecology and evolution. My ongoing dissertation research examines the relationship between both neutral and adaptive genetic variation in plains zebra (*Equus quagga*) across southern Africa and anthrax, a lethal disease caused by the bacterium *Bacillus anthracis*. I extracted DNA from zebra fecal samples and use the recently published horse genome to target candidate genes involved in immune response and anthrax etiology (*i.e.* MHC and *A\_TXRI*). Currently, I am assessing how diversity and selection in these host adaptive genes reflect the intensity and frequency of outbreaks within and across natural zebra populations.

## **OPTIMIZING THE OPERATION OF THE LETABA SYSTEM INCLUDING COMPREHENSIVE SURFACE/GROUNDWATER INTERACTION**

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The pressing need to conserve the sensitive ecology existing in the Kruger National Park (KNP) and at the same time satisfy other water demands in the Letaba River system is leading to a situation where the demand for water may have outstripped the system yield. During periods of low flow, releases made from Tzaneen Dam are meant to supplement the incremental flows and contribution from the tributaries downstream of the dam. Considering the demands, higher priority is given to KNP and domestic demands as compared to the irrigation demands. However, it has been noted that the releases made from the dam substantially fail to meet the anticipated supply. In order to improve the system's reliability in meeting the demands, there is a need to incorporate the streamflow modelling into the system operation. This progress report is about the situation assessment of the system, streamflow modelling done so far.

The situation assessment of the system includes (1) the physical characteristics of the system, (2) monitoring system, (3) the available information and (4) the current operation of the system. The streamflow modelling aimed at utilizing all the relevant available information. The fuzzy inference approach was considered because it is capable of incorporating uncertainties and requires less information as compared to other conventional models. Several objective functions which include the root mean square error, mean absolute error, logarithmic ratio of the observed and simulated and a multiobjective function have been used. The results indicated that none of these objective functions performed significantly better than others, this might be the result of the flows being heavily impacted by the hydraulic structures constructed at several locations in the Letaba. Further work in this study will involve the formulation of a model which incorporates the hydraulic structures and the operation of Tzaneen Dam.

## **PLANT AVAILABLE NITROGEN UNDER DIFFERENT WATER REGIMES IN A SAVANNA, KRUGER NATIONAL PARK**

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This study was initiated to determine how the combined effects of available water and nitrogen affect the savanna structure. My study concludes that different levels of N mineralization rates, facilitated by varying moisture levels and different vegetation cover, have significant effects on tree-grass dynamics. Variability in rainfall results in variable responses from soil microorganisms responsible for mineralization of important nutrients such as nitrogen. Plants then respond by competing for available resources including both nitrogen and water. Grass are stronger competitors for these resources, however the strength of their competition is regulated by variability in rainfall. Grass competition retard the growth of sapling and prevents them from reaching sizes above the flame-browse trap. My study has also shown that the effects of rainfall in savanna cannot be considered in solitude without recognizing its impact on N mineralization rates. In general, drier rainfall cycles will favor trees, while wetter rainfall cycles will favor grass.

## DETECTING CHANGES IN ELEPHANT BODY CONDITION IN RELATION TO RESOURCE QUALITY

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One of the major concerns around elephant conservation and management is the impact that they have on vegetation in enclosed areas. This issue can be extended to the problem that elephants may become limited by resource availability. In accordance with optimal foraging theory, elephants should consume the highest quality food sources first, switching to lower quality foods as the abundance of the higher quality foods decreased. This would result in them consuming food of declining quality over the years, possibly to the point where sufficient nutrients to maintain condition are no longer available, thereby resulting in a decrease in body condition. This may then extend to reduced fitness, as predicted by density dependence. This project addresses this hypothesis. We predicted that this decrease in available nutrients would affect life stages that are vulnerable to energy stress more than others. These vulnerable life stages were identified as newly weaned calves, lactating females, and old females who were experiencing loss of tooth function. Non-lactating females and sub-adult females were identified as non-energy stressed life stages. We predicted that body condition would also differ seasonally with changes in the availability of resources. We also predicted that, due to the high density and long occupational history of the elephants in the Addo Main Camp (AMC), resource quality would be lower there than in the Nyathi Concession Area (NCA), with the elephants in the NCA thus also exhibiting better body condition. Our results show a significant difference in body condition between life stages ( $X^2 = 51.79$ ,  $df = 9$ ,  $p < 0.001$ ), with non-energy stressed individuals exhibiting better condition than energy-stressed individuals (Fig 1). Of the three energy stressed life stages, weaned individuals had the best condition, almost equalling that of the non-energy stressed individuals, and even exceeding their condition in summer. The worst body condition was found in old individuals, with lactating individuals exhibiting intermediate condition. Body condition was also found to differ significantly between seasons ( $X^2 = 57.63$ ,  $df = 9$ ,  $p < 0.001$ ), with the best condition in winter for all life stages

## **DETECTING CHANGES IN ELEPHANT BEHAVIOUR, SOCIAL INTERACTIONS AND DEMOGRAPHICS IN ADDO**

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The objective of this project was to use the existing data and expand upon it to address a further set of questions regarding elephant biology over a five-year period (2007 – 2012). These include monitoring the population's demographic trends (growth rate and density), individual life history events (births, deaths, oestrus, and musth) and maintaining the Addo elephant individual recognition database. Seven monitoring trips were conducted in the year under review.

The mean percentage growth rate of the Main Camp elephant population during 2004-2008 was  $4.6 \pm \text{SD } 2.4$  (earlier years are excluded as the population was split in 2003). The mean density for the same period was  $3.16 \pm \text{SD } 0.26$  elephants/km<sup>2</sup>. As of the 27<sup>th</sup> November 2008, the Main Camp population numbered 415 and the density was 3.5 elephants/km<sup>2</sup>. The population of the Nyathi concession was 89 individuals for the same date, and had a mean percentage growth rate of  $6.9 \pm \text{SD } 4.9$  for the period 2004-2008.

## FORAGING ECOLOGY OF THE BLACK RHINOCEROS (*DICEROS BICORNIS*) IN THE THICKET BIOME OF THE EASTERN CAPE

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The Thicket Biome supports the highest density of black rhinoceros in the world, and given the endangered status of the species, has the potential to play a significant role in its conservation. We investigate the foraging patterns, and hence conservation opportunities of black rhinoceros in relation to bio-climatic and landscape variations in browse availability, as well as variations caused by the conservation management of co-occurring large herbivores (elephants).

Black rhinoceros consume a wide variety of plant species (92 species in the Elephant Area of the AENP) and they would appear to be more flexible in their diet than previously suggested. Results support the hypothesis that black rhinoceros are able to modify their diet in relation to differences in plant community structure and season, able to broaden their diet (generalise) as resources become limiting in more arid landscapes. Changes in grass utilisation are the most obvious shift in diet (may be the dominant food item, contributing up to 30% of the diet in the Elephant Area), where the relative availability of grass varies between plant communities and high and low rainfall periods. These results call into question the traditional perception that black rhinoceros are exclusively browsers (global average of grass utilisation equals 1-5 %), and suggest that they are more versatile in their diet. Although black rhinoceros displayed changes in resource utilisation between seasons and plant communities, differences in dietary quality (P, Fat, Ash, Total Fibre and Lignin) were only observed between plant communities. Elephant and black rhinoceros display a large overlap (i.e. potential for interspecific competition) in dietary resource utilisation. Seventy-nine, of the 90 and 92 plant species identified in the diet of elephant and black rhinoceros, respectively, were utilised by both species. A 64% overlap in utilisation was obtained when considering the abundance of these plant species in the diet of the animals. Results further suggest that potential browse availability for the black rhinoceros is reduced in areas with no elephant utilisation and those exposed to long-term utilisation by elephants. The over-utilisation of thicket vegetation by elephant compromises the potential of this vegetation type to contribute to black rhinoceros foraging, and hence conservation opportunities.

## DETECTING CHANGES IN BUFFALO DIET IN ADDO IN RESPONSE TO THE REINTRODUCTION OF CARNIVORES

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Lions were reintroduced into the Addo Elephant National Park (AENP) in 2003, after an absence of over 100 years. It is expected that this would have lethal and non-lethal effects on the buffalo (*Syncerus caffer*) population in the park. This study investigates the non-lethal effects of lions on buffalo, by testing the hypothesis that the reintroduction of lions to the AENP has altered the habitat use of buffalo, and subsequently caused a change in buffalo diet. Microhistological analyses were used to analyze 40 faecal samples to determine the seasonal diet of buffalo. Autumn and Winter samples were compared to a study by Landman & Kerley (2001) (prior to lion reintroduction), to test the effects of the lions on the diet of the buffalo population. A total of 38 plant species, dominated by grasses (76.3%), were identified in the diet of buffalo. Summer and Spring samples showed the greatest variation in species consumed. The study shows a change in the buffalo diet after lion reintroduction. This change in buffalo diet may not only be due to the presence of carnivores but also due to other factors. Competition with other herbivores (e.g. elephant and warthog), a shift in habitat structure (availability and quality) from other species and seasonal variation may also be used to explain the change in buffalo habitat use and diet.

## **A PREDICTIVE MODEL TO IDENTIFY THE LOCATION AND EXTENT OF SODIC SITES IN THE KRUGER NATIONAL PARK USING REMOTE SENSING TECHNIQUES**

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The aim of the project is to produce a digital map of the sodic sites found in the entire Kruger National Park from digital images obtained using remote sensing, and digital image classification. The initial intention of this project was to include hyperspectral imagery, a short investigation was made into using this high spatial (1.12m), high spectral (72 bands) resolution imagery to classify sodic sites on the Ripape River. The result of an unsupervised pixel classification is that the very bare centre of the sodic sites are spectrally different to other bare soils in the visible to near infra-red bands and were used to classify sodic sites using object-based classification using Definens Professional. The short wave infra-red bands were not provided in this dataset and it would be useful to include these bands in future hyperspectral data as soil and geology spectral differences are more distinct at these longer wavelengths.

## **THE ROLE OF MEGAHERBIVORE BEHAVIOR IN DRIVING FIRE-GRAZING INTERACTIONS AND GRASSLAND COMMUNITY STRUCTURE: “COMPARING PROCESSES ACROSS CONTINENTS”**

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The goals of our project continue to be (1) to compare how ecosystem and community structure and function respond to key ecological drivers (fire and grazing) in South African vs. North American savanna grasslands, and (2) to identify those ecological processes that are similar (convergent) despite the potential contingent factors of differing evolutionary history, herbivore diversity and soil fertility.

We found that the response of grassland plant diversity and species richness to loss of a single herbivore species was similar between the study sites in North America and South Africa. Reduction in herbivore richness from a single large herbivore species to no species resulted in a decline in plant species richness and diversity in both systems. However, in Kruger when multiple herbivore species were present, plant richness and diversity were intermediate to that with a single herbivore or when herbivores were excluded. While plant species richness and diversity were lower in sites with multiple herbivores than with a single herbivore at Kruger, the composition of local-scale (4-m<sup>2</sup>) plant communities in the multiple herbivore site was significantly different from the other sites with either a single or no herbivores, and local communities within these sites were much more similar to each other than either was to the multiple herbivore site.

Differences among sites were largely driven by strong shifts in the relative abundances of six dominant grass species at Kruger, while at Konza site differences were driven by changes in the relative abundances of a diverse suite of forbs and grasses. In contrast to the findings based on plant richness and diversity, these patterns suggest that reduction of herbivore species richness from many species to one may result in large changes in the plant community via shifts of species composition.

## **VEGETATION RESOURCE DISTRIBUTION AND DYNAMICS ASSESSED USING HYPERSPSPECTRAL (AND BROADBAND) REMOTE SENSING AND THE RESPONSE OF WILDLIFE IN THE SOUTH AFRICAN SAVANNA**

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The research project aims to map the distribution of different grass leaf biochemicals considered to act as attractants and deterrents of wildlife, the mapping will be done using remote sensing. The distribution of the biochemicals is to be mapped over the Kruger National Park (KNP) and this will then be related to wildlife distribution. In answering the question of the effects of season on the biochemical concentrations, we observed that biochemicals do fluctuate seasonally. Other researchers have shown that many savanna grass species respond rapidly to fire events with an increase in nutrient concentrations, the longer term effects are less known. This information is an important detail in determining the feasibility of mapping biochemicals with imagery that is not current. Broadly our investigation showed that if one compares the same species after different burning treatments we showed that Nitrogen levels increased in all burnt plots, and Phosphorus levels increased in plots that were burnt multiple times. What we did observe though is that these effects were non-significantly different to unburnt areas, however we believe with increased sampling the trend would be clearer and differences significant. A factor that was revealed is that it is important to consider species separately as certain species show a far stronger response to burning than others.

## THE ROLE OF ELEPHANTS IN ENHANCING SPECIES RICHNESS

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The research focuses on understanding the effects of elephants on browse production and the quality of browse. The responses of browsed trees, stems, branches, or pushed over trees were measured in terms of changes in the availability of browsable biomass and forage quality at different feeding heights. The changes in available biomass will be calculated not only for elephants but also for other browser species (e.g. impala, kudu, steenbok). Individual browsed trees (with different elephant impact, such as pushed over trees, or trees with changes in canopy architecture) will be identified and browse biomass and quality will be estimated at different feeding heights. In addition, a defoliation experiment will be carried out, comprising different defoliation intensities and aimed at studying the effect of season, and the effect of the browser return period on the availability and quality of the browse. This experiment is aimed at understanding how the browse intensity and timing of the browsing events influences the browse biomass and quality

## **BIODIVERSITY AND RESILIENCE OF RIPARIAN VEGETATION UNDER DIFFERENT MANAGEMENT REGIMES**

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The aim of the study is to test and further develop recently developed methods for measuring resilience in vegetation.

Traditional species richness (Margalef and Menhinick), evenness (Pielou) and diversity (Shannon-Wiener and Simpson) indices have been calculated for the woody species dataset. First order streams were found to have much higher species richness and diversity than the main river. Differences between management zones were also evident. While main river sites were similar across zones, first order streams in the communal lands had higher species richness, lower evenness, and higher diversity than first order streams inside the conservation areas. This raises interesting questions about biodiversity conservation in protected areas. Further investigation is, however, needed before conclusions can be drawn. For example, the indices mentioned above do not take into account the degree of (taxonomic or functional) difference between species, which is an important component of diversity.

Beta diversity, or the amount of species turnover between plots, was higher along the main river than along first order streams. In other words, plots on the main river differed more from each other in species composition than plots on small streams. This reflects the stronger elevation gradient on the main river and the tendency for species to have characteristic preferences along this gradient. Although species on the first order streams were patchily distributed, the average turnover between plots was similar. Specific leaf area and leaf tensile strength were both continuously distributed among species, with a reasonable spread of values.

## **A BRIEF PROJECT DESCRIPTION FOR CONSIDERATION BY SOUTH AFRICAN NATIONAL PARKS TO ALLOW FOR A SURVEY TO BE DONE WITHIN PARK BOUNDARIES OF WOODY INVASIVE ALIEN PLANTS**

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The development of a cost-effective, objective, statistically sound and therefore repeatable monitoring system of woody invasive alien plants at quaternary catchment level. The system will produce a map and procedure to continuously update the map of the national distribution of woody invasive alien plants.

The objective of the analysis of the SAPIA database (Henderson, 1998) and the modelling was to determine the feasibility of using environmental variables (steepest environmental gradient) to stratify the study area for sampling purposes. Results as reported in Kotzé *et al.* (2007) proved that even a limited number of environmental variables and their interactions are important for stratification. However, the spatial distribution of the SAPIA database is too coarse and a more refined spatial database is required; therefore the choice of the number of main effects and their subclasses (to be used in the interaction) is of strategic importance. Furthermore, demarcation of environmental variables should be done at a tertiary catchment level, implying that subclasses must be created within a tertiary catchment. Too few subclasses will result in tertiary catchments having one to two demarcated areas (strata) per main effect, for example rainfall. Too many subclasses will result in excessive incomplete factorial designs. It was found that using four main effects, namely rainfall, soil depth and clay B content (3 subclasses each), and terrain (2 subclasses), was the most effective in minimizing incomplete factorial designs.

## ELEPHANTS AS TEMPORAL AGENTS OF HETEROGENEITY IN THE SEEDLING RECRUITMENT PHASE

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The project aims (1) to determine the temporal patterns of seed dispersal by elephants, (2) to determine the potential of elephants as agents of seed dispersal via seed ingestion and defecation, and (3) to quantify whether elephants act as facilitators for seed germination and seedling establishment, through the ingestion of seeds.

The study area comprised the south of the Orpen- Satara- N'wanetsi area. In May this was changed to the area between Orpen, Satara and Tshokwane.

The results show that this year (2008) elephants dispersed seeds between January and July. No intact seeds have yet been found in pellets from other browsing herbivores.

Eighteen different seed species have been encountered in elephant dung. These included *Sclerocarya birrea*, *Grewia villosa* and *Acacia* species. All other species still need to be identified. The *Grewia* species were represented in the highest quantities.

Seeds of 8 different plant species have been planted in a nursery of which only *Grewia villosa* germinated.

## **HABITAT AND FORAGE DEPENDENCY OF SABLE ANTELOPE (HIPPOTRAGUS NIGER) IN THE PRETORIUS KOP REGION OF THE KRUGER NATIONAL PARK**

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This study is aimed at establishing the causes of the decline of low density antelope species in the Kruger National Park (KNP). The goal is to gain a better understanding of habitat and forage dependency by sable antelope at different spatial scales in a region where the largest sub-population persists. The study focuses on four herds occurring in the Pretoriuskop region i.e. in the vicinity of Numbi gate, Phabeni gate, Shitlave dam and Nhapi boulder.

It seems as though the sable utilize the different areas within their home range to a different extent, with areas of intense and intermediate use and areas within the home range that are not utilized. A large number of faecal samples have been collected from all four herds and these will be stored for microhistological identification of the grass species consumed. This will however only be done at a later stage. All faecal samples collected have been analysed for the nitrogen and phosphorus content.

## **A SCALED, CONTEXTUAL PERSPECTIVE OF WOODY STRUCTURE AND DYNAMICS ACROSS A SAVANNA RIPARIAN LANDSCAPE**

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The study covered the full extent of these rivers from the western boundary fence to the high-level bridge over the Shingwedzi (just east of the confluence of the Mphongolo and Shingwedzi).

LiDAR and high-resolution aerial imagery were integrated through object-based image analysis to create spatial representations of woody structure (canopy height, canopy cover, canopy height diversity and canopy cover diversity) across a portion of the savanna landscape (60 000ha). Temporal change in woody cover and heterogeneity (number and size of woody patches) was assessed from a historical aerial photography record, that spanned 59 years from 1942 to 2001. Spatial relationships between environmental variables and patterns of woody structure and dynamics were tested at broad (100ha), medium (10ha) and fine-scales (1ha) through canonical correspondence analysis (CCA). The relative contribution of different categories of environmental variables, to the total explained variation in woody structure, was assessed at each scale through partial canonical correspondence analysis (PCCA). Spatial variation in environmental variables, and the influence of spatial context on woody structure-environment relationships, was explicitly tested through geographically weighted regression (GWR).

LiDAR results provided an unprecedented basis from which to explore spatial patterns of woody structure in an African savanna. Standard approaches to generating normalized canopy models (nCM) from LiDAR suffered interpolation artifacts in the heterogeneous landscape, but an object-based image analysis technique was developed to overcome this shortfall. The fusion of LiDAR with aerial imagery greatly enhanced the structural description of the landscape, and the accuracy of canopy height estimates varied between different vegetation patch types.

## **IMPACT OF HEUWELTJIES ON BIODIVERSITY & SMALL-SCALE DISTRIBUTION PATTERN OF ARTHROPODS**

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The main objective is to assess the influence of heuweltjies on ants and termites. We want to know which species inhabit heuweltjies and how the species and population pattern associated with heuweltjies differs from the surrounding habitats. As the vegetation of a heuweltjie is changing along a transect leading from the centre towards the surrounding, we want to know how the species pattern of arthropods is related to this gradient. Some ants and termites were collected at the BIOTA Observatory Koeroegapvlakte to get a first impression of the local fauna. No specimens were collected at the Observatory Numees. Due to time constraints, no difference between the fauna on and off heuweltjies are assessed.

## **ANALYSIS OF CATENA HYDROLOGY WITHIN THE HERBIVORE AND FIRE EXCLOSURES ON THE SABIE AND LETABA RIVERS, KRUGER NATIONAL PARK**

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The project aims at an understanding of lateral fluxes of water from crest to riparian zones in catenas through various herbivore and fire treatments inside and outside of the exclosures. This understanding will allow for management decision making to include the interrelationships between ecotones within upland to riparian catenas under different treatments. Further, the project is aimed at quantifying the soil-water-plant-atmosphere relationships within each ecotone in upland to riparian catenas. This will allow management decisions to include for the consequences of short and long term perturbations to ecosystems as a result of climate change and variability.

The water contents at the combretum site have a low water holding capacity and remain very dry over full profile in winter. The sodic profile has a higher water holding capacity and responds rapidly to rainfall events. This response occurs over the top 700mm of the profile, while a slower wetting response occurs at 1000mm below surface. Significant water retention is evident during winter, possibly due to “capillary break” effect of the surface. At the riparian site, the full profile wets up during a 75mm rainfall event. The drying of the upper layers in response to evapotranspiration is slow, while the base of the profile remains wet for the entire period, most probably due to upslope accumulation of subsurface water.

## **TUBERCULOSIS IN LIONS (PANTHERA LEO) IN SOUTH AFRICA, EVALUATION OF THE IMMUNE RESPONSE TOWARDS MYCOBACTERIUM BOVIS**

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The main goal of the presented study was to develop better insight in the development of the immune response of lions infected with *M. bovis*. Ultimately this knowledge should support control and/or prevention strategies.

A multi-species IFN- $\gamma$  ELISA was optimized for lions, but the ELISA could not be completed due to difficulties that were experienced in the process of optimization of the test. Cloning and sequencing of the lion IFN- $\gamma$  gene has been performed, which is a first step in development of a lion-specific IFN- $\gamma$  ELISA. Comparison of the sequences of the lion, cheetah and domestic cat IFN- $\gamma$  genes showed high similarity suggesting that this IFN- $\gamma$  ELISA may also be used in other felid species .

Cell mediated immunity (CMI) is likely to be measurable (skin test, IFN- $\gamma$  assay) in early stages of infection only, To determine BTB infection status in lions in later stages of the disease, indirect ELISA's were developed for the recombinant antigens CFP10 and DiaSer3. Test characteristics of these two iELISA's and the MPB70 and MPB83 iELISA's, showed that, with a high specificity, the iELISA's for these four antigens have low sensitivities –a difficulty of serology-based tests that is generally acknowledged and that might be avoided by using multiple recombinant antigens together. The four iELISA's were subsequently used to test the KNP lion serum samples collected during the field surveys (n= 225.), classifying a low number of samples as positive.

## RESOURCE PARTITIONING BETWEEN LOW DENSITY AND HIGH DENSITY GRAZERS: SABLE ANTELOPE, ZEBRA AND BUFFALO

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The aims of the project were, to assess space use and movement patterns of sable antelope, zebra and buffalo in order to determine differences in diet composition between these species and to determine the quality of the diet obtained by these species at different stages of the dry season.

Results show partitioning of resources at the scale of the home range, with sable occurring in sections of the study area with less concentration of buffalo or zebra and avoiding areas close to water sources where buffalo and zebra concentrated during the dry season. Sections of the landscape used by sable retained greener grass than areas used by buffalo or zebra, which tolerated the widely available brown grass. However, sable and buffalo revealed similarity in woody vegetation cover of habitats used, both occurring in woodlands with 25% woody cover, whereas zebra used more open habitats with less than 10% woody cover. The diet of sable overlapped more with the diet of buffalo than with the diet of zebra. Similarity between these grazers in resource use at the feeding site and feeding patch level suggest potential for competition for food.

Accordingly, reducing the concentrations of buffalo and zebra through closure of artificial water points and fire management is fundamental for the conservation of this low density and declining antelope species.

## **CORRELATION BETWEEN TETRACYCLINE RESISTANCE IN ESCHERICHIA COLI ISOLATED FROM IMPALA AND ESCHERICHIA COLI ISOLATED FROM THEIR WATER SOURCE**

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The purpose of this study was to find a relationship between tetracycline resistance shown by *E. coli* in untreated animals and the presence of tetracycline resistance in their water source. The study areas of this project involved 5 km buffer zones around the water sampling points on the following rivers: Crocodile, Letaba, Olifants, Sand and Sabie. The Crocodile, Letaba and Olifants rivers showed the presence of intermediate *TREC* (MIC=8mg/L), although only in 25% (n=4) of the water samples positive for *E.coli* (n=16). In contrast, the Sabie and Sand Rivers, none of the water samples were positive for *TREC*. All the water samples that showed resistance were collected in March. The faecal samples of impala where *E. coli* showed tetracycline resistance, were distributed over all three of the collection periods (March, May and July).

The study showed that *TREC* can be found in the Crocodile, Letaba and Olifants rivers. This finding adds information to the database of the KNP concerning patterns in water and landscape, which try to interpret the ecology of unnatural threats leading to compositional changes, revealing that antimicrobial resistance is an integral part of the pollution status of these rivers. The presence of *TREC* also appeared to be related to the period of major usage of tetracyclines e.g. summer usage for prophylaxis and therapy of protozoal diseases. Moreover the research validated the possibility that tetracycline resistance can be likely spread through river water to naïve wildlife, such as impala. The presence of *TREC* in impala all along the different collection periods showed that once AMR is gained it is likely to be maintained even in the absence of selective pressure i.e in animals not treated with antibiotics. Since AMR can be transferred within and between bacterial species, it may be possible to extrapolate these findings to the possibility of the spread of antimicrobial resistance within the environment in general, indicating that AMR is not only linked to antimicrobial therapy of animals. Furthermore awareness for environmental antimicrobial dissemination based on water transport should be addressed.

## **A PROPOSAL TO STUDY STABILITY, RECOVERY AND RESILIENCE IN PIOSPHERE SYSTEMS IN THE KRUGER NATIONAL PARK**

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The aim of this study was to resurvey piosphere systems in the Kruger National Park, previously described by Thrash in 1990. The objectives of the project were to document spatio-temporal change in soil infiltration rate, compaction, soil fertility, herbaceous community composition and structure, herbaceous basal cover and woody plant community composition and structure.

The main conclusion to date is that piosphere recovery appears driven largely by climatic factors rather than waterhole closure *per se*, within the time period under examination, and that waterhole closure is a viable management tool to restore historical herbivore utilization patterns.

## VARIATION WITHIN AND AMONG CHILOGLANIS SPECIES FROM THE RIVER SYSTEMS OF THE KRUGER NATIONAL PARK (KNP)

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The study focuses on the three species of *Chiloglanis* that are used as indicators of the health of the river systems using both molecular and morphological approaches. Each *Chiloglanis* species prefers a particular habitat, which is characterized by a particular flow regime, height of the water column and availability of stones or sand. In the high mountainous streams with rocks in flowing water, the species of *Chiloglanis* that is likely to be found is *C. pretoriae* in contrast to *C. swierstrai* (Jubb and Le Roux, 1969). The latter is a downstream dweller that lives over sandbanks, burying itself in the loose sand (Skelton, 1993) whereas *C. paratus* prefers rocky riffles with relatively higher water column. The three species were collected from the river systems in KNP in August 2007 and these samples will be compared with populations of the same species collected elsewhere in South Africa and neighbouring countries. There were more than thirty (30) sites sampled in KNP of which eight (8) sites had at least two species of *Chiloglanis* recorded (Appendix I, II). The records suggest that the park has relatively high biodiversity (26% of the sites have at least two *Chiloglanis* species recorded in contrast to eight percent we have recorded in the same river systems outside the park during our November 2006 surveys), which may imply that the water resources are of fairly good conditions in the park.

## **POLLINATION ECOLOGY OF SOFT-WINGED FLOWER BEETLES (INSECTA: COLEOPTERA: MELYRIDAE) IN KRUGER NATIONAL PARK**

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This project will help park managers achieve park goals of better understanding insect biodiversity and the contributions that insects make to key ecosystem processes such as pollination. To date, we have conducted landscape-scale surveys of insect floral visitors in the Skukuza ranger district, Kruger National Park, South Africa. In 2006 and 2007, insect visitors were collected from flowers of 196 trees and shrubs representing 16 plant species. Dry season sampling was conducted in September, 2006, and rainy season sampling was conducted in November and December, 2007.

In our first two years of sampling, beetles (Order Coleoptera) comprised 62% of floral visitors; ants, wasps, and bees (Order Hymenoptera) comprised 26% of floral visitors; butterflies and moths (Order Lepidoptera) comprised 6.3% of floral visitors; and species of the insect orders Blattodea, Diptera, Hemiptera, and Neuroptera were also found on flowers. Bees (Insecta: Hymenoptera: Apoidea) had the most extensive pollen loads, while species of the beetle family Scarabaeidae also transported pollen. Species of the beetle families Melyridae, Cleridae, and Coccinellidae were also observed with pollen loads. The tree and shrub species that we sampled appear to have generalist pollination systems, with the exception of species of *Grewia* L., which appear to be primarily pollinated by bees.

## **ECOLOGY OF TIGER BEETLES (INSECTA: COLEOPTERA: CICINDELIDAE), WITH FOCUS ON RIPARIAN SPECIES**

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This project will provide basic ecological data on tiger beetles found in riparian and riverine areas of Kruger National Park. Many species of tiger beetles are in decline worldwide (including several taxa in South Africa) and better ecological data is needed to better manage populations of these insects. Data from this project will help Park staff to better understand the status of these beetles and also help meet Park objectives for managing invertebrate biodiversity.

In September, 2006, I studied the dry season ecology of tiger beetles at fifteen discrete sites along the Letaba, Olifants, and Sabie Rivers in Kruger National Park. Thirteen sites yielded adult beetles, with six species represented. Based on field observations, I was able to describe the microhabitat associations of adults of these six species and ovipositional/larval substrates of five of the six species.

## **IMPLEMENTING STRATEGIC BIODIVERSITY MONITORING FOR CONSERVATION OF THE KRUGER NATIONAL PARK RIVERS**

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The main objective of this project was to look into and instigate proposed adaptive management processes for the rivers of the KNP. To a large degree this was to revamp the river TPCs for future use within the Strategic Adaptive Management process. A major outcome was the River TPC workshop held in February of 2007 which helped pave the way for future use of river TPCs and broader issues surrounding the adaptive management of rivers. An integrated strategy for river monitoring was documented (see attached file), including river flows and water quality, biodiversity related TPCs and incorporating the River Health monitoring efforts. Linking with the terrestrial biodiversity monitoring programme has been discussed and will be incorporated as far as possible. Current issues regarding strategic adaptive management for rivers and associated integrated catchment processes are important and have been considered. Additionally, capacity within SANParks has been highlighted and processes are being put in place to address this issue. All this has culminated in a new strategy for longer-term research and management involving the Kruger rivers, but also for other relevant parks under management of SANParks.

## ARCHAEOLOGY AND CULTURAL HERITAGE IN MAPUNGUBWE NATIONAL PARK

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This project investigates the place of culture and nature in Mapungubwe National Park, specifically, we examine the iniquities of past research based at Mapungubwe, the public representation of the site and its landscape, which is a direct result of the formers' legacy, and to explore the role of ethics, conservation, tourism, biodiversity and education. We are concerned with the marketing of heritage, from provincial to national levels, as well as the attendant concerns of economic development and social uplift. Moreover, we look at how the site is conceptualized now and how the numerous stakeholders are incorporated and balanced.

Findings suggest that communities would like to see aspects of their traditional culture represented at the new interpretive centre, such as utensils used in the home (reed mats, baskets-including winnowing baskets, beads made from plant seeds, grass bangles, clay pots). They also feel that the park should work more consultatively with them and address some pertinent issues such as help with transport to access the nearest health facilities, access through the park, access to plant resources, access to fishing (which was allowed before), and compensation for livestock and crops eaten by park animals. From the park side there is a feeling among some of the management that the park is too small to explore or allow local community access to resources within the park boundaries.

## **BEHAVIOURAL ECOLOGY AND CONSERVATION BIOLOGY OF THE CHEETAH IN THE K GALAGADI TRANSFRONTIER PARK**

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The aim of the project is to identify the ecological role, behavioural adaptations, demographic parameters, conservation status and threats to the cheetah in the southern Kgalagadi ecosystem.

One of the most significant observations we have made over the first two years of the Kgalagadi Cheetah Study is the low rate of reproduction of the females. Most adult females we have encountered are either without cubs or with only one. There are exceptions, two females in the Nossob area both raised four cubs to independence in 2006 – 2007 and a third female in the same area successfully raised three. In order to obtain detailed information on this very important aspect of our study we have radio collared seven females.

## **THE IMPACTS OF INVASIVE ALIEN PLANT CLEARING ON RIPARIAN VEGETATION RECOVERY ALONG THE SABIE RIVER IN THE KRUGER NATIONAL PARK**

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The broad aims of this study were to investigate impacts, ecology and efficacy of IAP clearing techniques, to assess the efficacy of the WfW programme in clearing alien plant invasions and to determine the extent of natural ecosystem recovery after clearing of IAPs in the KNP.

In general, alien species richness has increased slightly in the KNP over the last ten years. However, the invasion intensities have remained exceptionally low, even in the face of several large disturbance events that are usually associated with a sharp increase in alien plant invasions. This is more than likely attributable to the continuous annual clearing operations by WfW in the KNP. Continuous clearing acts to effectively limit the establishment and spread of many IAP species despite the ever present threat of invasion from upstream. Furthermore, the continuous clearing of IAP stands in the KNP ensures that stands are relatively short-lived, preventing long lasting negative impacts on the ecosystem. Removal of IAP species reduces their disproportionate competitive influence and facilitates the natural re-establishment of native vegetation.

## **INTEGRATED MANAGEMENT OF ICONIC NATIONAL PARKS: A COMPARATIVE STUDY**

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This research is designed to develop thresholds of acceptable change associated with the effects of tourism on local communities. The research focuses on two iconic national parks, Kruger National Park (KNP) in South Africa and Purnululu National Park (PNP) in the eastern Kimberley region of Western Australia. Both case studies provide good opportunities to explore issues of social equity, tourism sustainability and adaptive management practices.

The concept of Thresholds of Potential Concern (TPC) is well developed in the ecological literature, with TPCs being used to explicitly link management objectives with on-ground management actions. Kruger National Park is regarded as a leader in the field with their use of TPCs to guide management; although their lack of social research is an identified shortcoming (TPCs developed to date in Kruger National Park are all ecologically based). Changes to the protected area management paradigm have resulted in an increased interest in protected area- community relations. The investigation of community concerns remains a significant research gap in the protected area management field and many protected area agencies are now looking to rectify this knowledge gap. As such, the application of the TPC concept to social (community) settings represents a new and timely direction for research. In the research, 'gateway' communities (those providing primary access points into the national parks and hypothesised as being exposed to the greatest effects of tourism) have been targeted.

Fieldwork has been completed in Purnululu National Park (Western Australia); fieldwork is currently in progress in communities adjoining Kruger National Park and will continue until November 2008. Initial analysis suggests an overall positive perception of the Kruger Park, with common negative issues arising concerning water provision/ access and the escape of dangerous animals from the park.

## THE IMPORTANCE OF DEW AND FOG PRECIPITATION IN ARID ECOSYSTEM ECOLOGY AND RESTORATION

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Experimental infrastructure comprising fog harvesters, fog exclusion chambers, plexi-glass open top warming chambers and control plots as well as environmental data loggers and sensors were installed at two sites, namely Numees and Koeroegapvlakte, situated along a rainfall and occult (fog and dew) precipitation gradient in the Richtersveld National Park. Respiration rates, water and organic matter contents and nitrogen and phosphorus concentrations were measured in the soils both in the ambient environment and in the fog exclusion and warming chambers. Also, Photosystem II function, leaf photosynthetic pigment concentrations, water and nitrogen and phosphorus concentrations were determined in the common succulent *Brownanthus psuedoschlichtianus* present in the ambient environment and in the fog exclusion and warming chambers.

## OPTIMIZING RESOURCE MANAGEMENT ACTIONS BY INCORPORATING THE SPATIO-TEMPORAL DISTRIBUTION OF ELEPHANTS

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The aims of the project were, to determine which factors influence wildlife management by different types of landowners in South Africa; to get an insight on effects of different management actions available to landowners (e.g. investment in forage manipulation, fire mgt, provision of artificial water points) to wildlife population dynamics and welfare of the landowners; and to understand the effects of cooperation and non-cooperation amongst landowners undertaking wildlife management and suggest actions for optimization.

The optimum herbivore offtake in the model was found to be 5% , 7% and 7% for elephant, white rhino and hippopotamus respectively. ABSA studies using empirical financial data for ranches in the lowveld region in South Africa, found the optimum offtake to be 11% and 14% for white rhino and hippopotamus respectively. In Kruger National Park elephants were removed through culling prior to 1995, although not done for commercial purposes but as a population management tool. The fraction of the total population removed through culling ranged from 0.2-20.9% and the median percentage of the existing population that was culled per year was 5.35%.

## **CONTRASTING COLLABORATIVE ARRANGEMENTS IN NATURAL RESOURCES MANAGEMENT USING A BEHAVIORAL APPROACH TO RELATIONSHIPS THEORY: CASE STUDIES OF RIVER AND FIRE MANAGEMENT SYSTEMS IN KRUGER NATIONAL PARK, SOUTH AFRICA**

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The project sought to advance understanding of the behavioral processes that influence social relationships in natural resources management.

The study revealed that for a long time fire management has been used in Kruger National Park in the maintenance of savannah rangelands. Although approaches to fire management have changed on a number of occasions, the study showed that two major phases have defined the nature and substance of collaborative arrangements in fire management, pre-2002 and post-2002. These phases have been largely shaped by the level of professional/social agreement on assumptions and level of certainty about outcomes.

The study revealed that, with high levels of abstraction and regulation of river flow, the Kruger National Park has become increasingly aware of the risks of water shortage and the need to negotiate assured supplies. Water provision in the park ranks with fire as among the main management tools available to managers for maintaining savannah ecosystems. The management of surface water has been a major priority since the establishment of a water provision program in the 1930s. As with fire management, the study revealed that two major phases have defined the nature and substance of collaborative arrangements in water management, pre-1997 and post-1997. These phases have also been largely influenced by the level of professional/social agreement on assumptions and level of certainty about outcomes among the government, the national parks agency and other stakeholders.

This study illustrates that the major sociopolitical transformation that emanated from the 1990's governance changes in South Africa has led to changes in the nature and substance of collaborative arrangements in Kruger National Park. Whilst the internal collaboration between the scientists and managers of the park has proved to be effective to some extent, evidence suggests that collaborative arrangements – more especially those involving external actors – have generally not been performing as desired particularly by conservation agencies.

## THE ECONOMIC VALUATION OF FLAGSHIP MAMMALIAN SPECIES IN AFRICAN GAME RESERVES

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The objective of the project was to calculate use values of a number of flagship mammalian species in National Parks in Africa. Interviews of both international and domestic visitors to the restaurant/picnic area of Skukuza Rest Camp in Kruger National Park were conducted by randomly selecting visitors to complete a questionnaire to determine their willingness-to-pay towards mammal conservation in the park. The study provides some insight into visitors' views and willingness to pay towards mammal conservation in KNP.

The vast majority of visitors to Kruger National Park were in favour of protecting the current number and variety of large mammals found there; 70% of the respondent's who completed the questionnaire were willing-to-pay towards the conservation of mammals in Kruger. Of those respondents who were willing-to-pay for ensemble species conservation, the mean amount was R92.92 ( $\pm$  R18.95) per person per visit.

The percentage of respondents WTP for giraffe/elephant conservation was less than those who were willing-to-pay for ensemble species conservation; only 44% of respondents were WTP for giraffe- and 44% for elephant conservation. The mean amount respondents were WTP for giraffe and elephant conservation were similar to each other (R71.12 and R73.40 respectively). Significant factors influencing willingness-to-pay included the respondents' age, employment status and experience of visiting the Park. Aggregated willingness-to-pay values were estimated to be R87.3million ( $\pm$  R17.4million) per year for ensemble species conservation, R41.1million ( $\pm$  R17.8million) for giraffe- and R42.4million ( $\pm$  R14.3million) for elephant conservation.

## **RAINFALL PATTERNS, SATELLITE DERIVED PHENOLOGICAL CHANGES AND ANTELOPES USE OF SPACE**

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One objective of this project is to predict vegetation green-up patterns based on rainfall timing and amount, through the analysis of the relationships between vegetation phenology derived from satellite NDVI datasets and spatially explicit rainfall data from the ground based radar weather station. A second objective is to correlate observed vegetation greening-up patterns with sable antelopes distribution data. Ultimately, we want to develop a model to predict the consequences of changes in plant phenology over time on the use of space of sable and other antelopes, from spatially explicit predicted rainfall from global climate models (GCMs).

We have calculated the phenological metrics for the period 1985-1999 from the AVHRR dataset. We are currently working on the phenology metrics from MODIS from 2000 onwards.

## MAMMALS, OXPECKERS AND TICKS: INVESTIGATING CONDITIONALITY IN A VERTEBRATE CLEANING SYMBIOSIS

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The first objective was designed to determine if and how seasonal and spatial variability generate conditionality in the oxpecker/mammal system.

For one continuous year, four areas of KNP, two of high mammal use (presumably high oxpecker activity) and two of low mammal use (low oxpecker activity), were sampled monthly for ticks using the drag method. The locations selected for tick collections were the fenced and unfenced Makhohlola experimental plots in southern KNP, and a fenced and unfenced plot near Shingwedzi Research Camp in northern KNP. Five 100m long transects were dragged in the Makhohlola plots. These transects ran parallel to one another and were separated by 50m in the fenced plot and 25m in the unfenced plots. In the Shingwedzi unfenced plot, five 100m transects 25m apart were also dragged monthly. But because the Shingwedzi fenced plot measured 75m x 50m, I dragged ten 50m transects. Ticks were preserved in 70% ethanol and then analyzed at the Onderstepoort Veterinary Institute, Pretoria. Ticks were first identified by species and stage, after which the adult ticks were subjected to a Reverse Line Blot hybridization (RLB) assay. RLB allows multiple samples to be analyzed against multiple probes to enable simultaneous detection and differentiation of *Theileria*, *Babesia*, *Anaplasma* and *Ehrlichia* species. A total of 2304 ticks from ten species and 129 ticks from six species were collected in the Makhohlola plots and Shingwedzi plots, respectively. There was a significant difference in the number of ticks collected in the Makhohlola and Shingwedzi plots and in the fenced and unfenced plots. The number of ticks collected in the Makhohlola fenced and Shingwedzi fenced plots, and in the Makhohlola unfenced and Shingwedzi unfenced plots also differed significantly. There was no significant seasonal effect on the number of ticks collected. Twenty-seven percent of the 48 adult ticks analyzed were pathogenic. Twenty percent of the Makhohlola ticks analyzed and 30% of the Shingwedzi ticks analyzed were pathogenic. There was no difference between the percentage of pathogenic ticks collected in the fenced (25%) and unfenced (28%) plots, nor between the wet (28%) and dry (25%) season .

## **MAPPING ECOLOGICAL ZONES IN KRUGER NATIONAL PARK: POTENTIALS AND LIMITATIONS OF REMOTE SENSING**

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The main objective of the project is to examine the potential and limitations of satellite remote sensing in habitat mapping in Kruger National Park and propose ways to use remote sensing in habitat mapping and monitoring for conserved areas in South Africa. The vegetation zones or habitat types in Kruger National Park cannot be distinguished on moderate spatial resolution multispectral images on the basis of the detailed dominant tree species classification schemes in use. It can reasonably be mapped at lower scales on the basis of the geologic fertility strata of the park. This is because of overlaps in the vegetation species composition of the ecological zones based on dominant tree species. The main factors that affect accuracy of habitat mapping by remote sensing for large protected areas like Kruger National Park are image swath width (related to spatial resolution), habitat homogeneity, weather and image processing methodology. For example, the 16 zones that the research attempted to map are at a scale that is too detailed to be differentiated using Landsat TM imagery. Remote sensing has potential in the periodic assessment of vegetation condition like vigour and spatial cover as indicators of habitat quality in large protected areas in South Africa, such as Kruger National Park. This is because there are many logistical difficulties of conducting the work by ground surveys. The resulting periodic updates in the spatial data on habitat maps of the protected areas have potential use in planning management interventions as required. The use of remote sensing in periodic assessments of large protected areas in South Africa requires ready availability of the required imagery, image affordability as well as availability of appropriate technology (hardware, software and technical know-how).

## **A STUDY OF FUNGAL PATHOGENS ON NATIVE TREE SPECIES IN KRUGER NATIONAL PARK**

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The aim of the project were to identify tree pathogens and potential tree pathogens in the Kruger National Park (KNP). Results from this study, which should really be seen as a pilot study, show that in the Skukuza, Pretoriuskop and Lower Sabie areas no serious diseases of trees occur. This conclusion is, however, limited, as surveys by the principal researcher was only possible along the main roads, while all reports received from KNP staff was of tree mortality of several years ago. We identified two wood rotting fungi, *Phellinus* and *Ganoderma* sp., which are known to cause a slow rot of trees, eventually leading to mortality. These two fungi were found on isolated trees and are not considered a serious problem in KNP. Several species of Ophiostomatoid fungi were collected from elephant and other wounds in KNP. This included a previously undescribed *Ceratocystis* sp. Surveys for tree pathogens in KNP should be expanded to other ecological zones and vegetation types in the park to obtain a true picture of the disease situation in the park. Game rangers and research staff should all be familiarized with the symptoms and signs of tree diseases and should report the sighting of any such signs to enable investigation of the extant and importance of the symptoms.

## A STUDY OF THE POTENTIAL FUNGAL PATHOGENS OF TREES IN KRUGER NATIONAL PARK, WITH PARTICULAR FOCUS ON TERMINALIA SPECIES

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Fungal tree pathogens can have a devastating impact on the biodiversity and functioning of natural ecosystems. Although native pathogens are in balance (homeostasis) with the natural tree community, this balance can be upset by unusual environmental conditions, human and animal activity. It is also seriously threatened by non-native pathogens. Knowledge pertaining to the fungal pathogens of native African tree species is rather limited. In South Africa, very few studies have been done on the fungi on native tree species since the first half of the previous century. Many fungal pathogens require wounds for infection. A focus of our research group has been to study the Ophiostomatoid fungi, and their insect vectors, that infect wounds on trees. During a previous project, ending in 2007, wounds made by elephants in the Skukuza area were investigated for the presence of Ophiostomatoid fungi. This project has now been expanded to focus on the northern parts of KNP, targeting a different geographic zone. Due to restrictions in human resources and the magnitude of potential fungi that could be collected, our study focuses on: the Ophiostomatoid fungi; tree wounds on *Terminalia* spp. and *Adansonia digitata*; reports of tree mortality received from KNP staff. These trees were chosen as we already have funding and post-graduate students for studying them.

Only one visit to Kruger National Park has been made in 2008. This took place in February, visiting the Pafuri area of the park. A specific focus of this visit was to study *A. digitata* trees. Samples were collected from dead trees (two), as well as from elephant damaged trees and fungi are currently being identified.

## **LONG-TERM TREE DYNAMICS IN KNP: INTEGRATING SPATIAL STRUCTURE, PLANT DEMOGRAPHY AND DISTURBANCE**

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The proposed study will utilize a combination of field work, image analysis and modeling to investigate long-term tree demography in selected large-scale experimental plots in the savannas of Kruger National Park, South Africa where fires have been manipulated for over 50 years. Specifically, it will investigate how vegetation spatial structure and local neighborhoods influence tree recruitment, growth and mortality, and how the nature of such interactions changes across gradients of rainfall, fire and geomorphology. These data will be used to parameterize spatially explicit models of savannas to explore how future changes in precipitation, as is predicted by many climate models, might influence the structure and above-ground carbon sequestration potential of different savannas, and to evaluate how the inclusion of spatially explicit processes influences model outcomes and predictions.

The project is presently in its initial stages. The analysis of EBP aerial photos is currently underway. Aerial photo pre-processing and classification for control and annual burn treatments for one replicate string for each of the 4 sites (Mooiplas, Satara, Skukuza & Pretoriuskop) for the years 1983, 2000, 2003 and 2006 has been completed. Processing of the other strings is currently underway. Data analyses will only begin once these have been completed.

Additionally, we have also completed our first field season during which tree seedlings and saplings were measured and tagged in each of control plots. We will continue to monitor these over the next 2 years to estimate survival and growth as a function of competitive neighbourhoods.

## **SEISMIC MONITORING OF SOUTHERN AFRICA AND THE MOZAMBIQUE CHANNEL**

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The Council for Geoscience (CGS) is mandated by the Department of Mineral and Energy (DME) to report on earthquakes in the Republic of South Africa through quarterly seismological bulletins compiled from instrumentally recorded waveform data from 26 seismological stations comprising the South African National Seismograph Network (SANSN).

The location of the Mopani site is ideal for monitoring earthquake activity in southern Mozambique and the Mozambique Channel and thus a programme was implemented to approach the South African National Parks to install a seismological station at the site. The site was equipped during April 2004 using an existing vault that was constructed during a project hosted by the University of the Witwatersrand. The current equipment consists of a Guralp-CMG-40T extended short-period (30 sec) seismometer, 24-bit digitizer and an Earthquake Acquisition Recording System (EARS) model Micro recorder.

A program to address the delay in transmitting waveform data recorded by the SANSN to the CGS offices in Silverton was established during the first quarter of 2006. General Packet Radio System (GPRS), a mobile data service for wireless communications that operates at speeds up to 115 kilobits per second, compared with Global System for Mobile Communications (GSM) that operates at 9.6 kilobits per second, proved to be the most attractive in both transfer speed and cost. GPRS additionally supports a wide range of bandwidths that is particularly suited for sending and receiving large volumes of data. The CGS implemented the SeisComp data acquisition software, developed by the GeoForschung Zentrum (GFZ) (Potsdam, Germany), during the last quarter of 2005, which records waveforms in the internationally accepted MiniSEED format and additionally has a feature for automatic earthquake location. Presently, waveform data is communicated at 20 samples per second (sps) continuous data and 100 sps for triggered data.

Software to monitor station availability was introduced during January 2008.

## **TRANSLATING THE NATURAL RESOURCE POTENTIAL INTO INTEGRATIVE PLANNING OF SUSTAINABLE VELD MANAGEMENT**

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The overarching objective of this project is to analyse the effect of different land-use forms and intensities on the natural resources of a communal farm area in the Lowland Succulent Karoo in an interdisciplinary approach. The finally developed maps of the distribution of natural resources will form the basis for improved veld management of the farm and modelling of different land-use options as well as climate change effects in future. The patterns of distribution of natural resources with regard to land use (past and present) and landscape structures will be studied regarding soils and phanerogamous vegetation on two different scales in two closely interlinked tasks. On the macro-scale, the distribution of natural resources of large-scale landscape structures (hilltop, slope, valley etc.) under different historical and present land use intensities will be studied. The study also has to take into account the patchiness within these units (i.e., heuweltjies, dry river beds), thus, covering also the meso-scale.

The research activities for workpackage South-D7 in 2007 comprised a joint vegetation and soil mapping exercise on Soebatsfontein commonage by Dr Alexander Groengroeft & students and Dr Ute Schmiedel. Prior to the mapping activities, a satellite image (Google Earth) have been overlaid by a grid of 300 x 300 m and each node of the grid has been stratified according to main habitat types (e.g., deep red sand, heuweltjie veld with light coloured matrix and heuweltjie veld with dark matrix, outcrop areas) and land use intensities during the younger history (1980es and 1990es). The data on land use intensity were generously provided by Mr Floors Brand, former farm manager of the de Beers-farmland which belongs to the Soebatsfontein commonage today. Based on this stratification 5 points (nodes of the grid) per habitat type and land use intensity were selected randomly. This resulted in app. 70 selected points on the Soebatsfontein commonage. At these points plus 15 selected sites inside the Namaqua National Park adjacent to the commonage, a 10x10 m vegetation relevé (species inventory with project vegetation cover) has been conducted accompanied by a soil profile and soil sampling.

## **BUILDING ROBUSTNESS TO DISTURBANCE: GOVERNANCE IN SOUTHERN AFRICAN PEACE PARKS**

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This study uses 150 key informant interviews within two transboundary protected areas (TBPAs) in southern Africa, the Kgalagadi Transfrontier Park between Botswana and South Africa and the Great Limpopo Transfrontier Park between Mozambique, South Africa, and Zimbabwe, to address analytically how different governance structures of transboundary protected areas maintain robustness in response to various types of disturbance.

This study argues that the bottom-up institutional development and the slow, unforced evolution of governance in the Kgalagadi Transfrontier Park have allowed governing bodies to learn how to adapt and respond to transformations in the social-ecological system from an operational level. By contrast, institutional development in the Great Limpopo has struggled operationally due to the top-down imposition of the park on local-level communities and officials and the short time horizons permitted for goal attainment. However, top-down park formation has resulted in other accomplishments, primarily in bridging international boundaries. The central premise is that the national-level commitment to the Great Limpopo results in greater degrees of cooperation at a policy level than in a park that develops from the bottom-up. Such high levels of policy cooperation without parallel gains in operational cooperation have led to unexpected challenges in the Great Limpopo.

## **EFFECTS OF BROWSING AND SEASON ON DEFENCE AND GROWTH OF SELECTED WOODY SPECIES AT THE NKUHLU EXCLOSURES**

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The main research question of the project is: How are structural, chemical and physiological traits of common woody species in *Acacia nigrescens* – *Combretum apiculatum* savanna affected by variations in browsing and season? We assume that phenols, tannins and structural polysaccharides in woody plants function as defences by reducing browsing. Broadly, we expect N to decrease during the wet season and chemical defences to (1) increase during the wet season, and (2) increase in less defended species under browsing

## **VEGETATION CHANGES AT THE NKUHLU AND LETABA ENCLOSURES, KNP (2002 TO 2007)**

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The purpose of the project was to analyse data collected as part of the routine monitoring of vegetation at the Nkuhlu and Letaba enclosures to establish how the structure and composition of the vegetation (especially woody vegetation) has changed during the period 2002-2007 as a result of the enclosures. we realized the following: (1) the composition of the vegetation in 2002 was so different among the treatment plots that we are not able to detect effects on species composition of the enclosure treatments (2) we do not expect to find effects on abundances of most species because (a) too little time has passed since the erection of the enclosures, and (b) many of the species, including marula, occur in numbers that are too low or too unevenly distributed among plots to test effects on abundances, (3) we expect to find effects on population structures, plant heights and canopy diameters of certain, more abundant, species, (4) we expect to find effects on abundances above 1.5 m of the more common species, and (5) we expect to determine the relative preference of species by elephants. Furthermore, we discussed the possibility to include information about soil type (crest/foot slope) into the analyses to gain more detailed information about vegetation changes in the enclosures.

## INDIRECT EFFECTS OF BROWSING ON INVERTEBRATE COMMUNITIES AT THE NKUHLU EXCLOSURE

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The general questions were: Are there any differences in invertebrate richness, abundance and communities along the catena? Will different grazing/browsing pressures affect the invertebrate richness, abundance and communities differently? Richness and abundance of ground-living and herbaceous-layer invertebrates were estimated in three vegetation zones (the crest, foot slope and riparian zone) in the fire-protected parts of the full enclosure, partial enclosure and control plot at the Nkuhlu enclosures in March 2008. The indirect effects of ungulates on invertebrate richness and abundance were highly context dependent. Responses varied between vegetation zones, and within/between different taxa. Sometimes the results indicated differences between the two enclosures and the control, suggesting that elephants and giraffes influence the system differently from other herbivores. Invertebrates were, for instance, more numerous in the absence of elephants and giraffes.

## **GENETIC MAPPING OF LEOPARDS PANTHERA PARDUS ACROSS THEIR SOUTH AFRICAN DISTRIBUTION RANGE**

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The aim of this project was to gather as many leopard skin samples as possible across South Africa and genetically analyse the samples in order to identify whether major differences exist in a species with a continuous distribution range. It was hypothesised that the genetic makeup of leopards across SA should be relatively uniform. No extensive research has previously been done with the only SA animals being tested originating from KNP, but none from any other region including KZN or the Eastern and Western Cape. The genetic variability in a species is an important consideration when animals are relocated and care should be taken not to artificially introduce foreign genes into a population indicating a high degree of divergence. The initial project has thus far merged with another one based at the University of Stellenbosch where all samples were sent to. The combined number of samples is around the 200 mark with samples ranging throughout most of SA and neighbouring countries. Preliminary results have shown that no significant differences exist between SA leopards, with some slight variance starting to show in the Mozambican samples. Sample gathering is a time-consuming process which is still underway. Upon completion, it is hoped that proper guidelines can be offered for consideration when leopards are moved in order to limit the artificial introduction of foreign genes into a genetically dissimilar population.

## **ASSESSMENT OF FACTORS DETERMINING FORAGE QUALITY AND QUANTITY WITHIN AND OUTSIDE OF THE ROAN ENCLOSURE, NORTHERN BASALT PLAINS-KNP**

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The purpose of the project is to elucidate possible factors underlying the roan antelope population performance inside as against outside of the study enclosure; thereby facilitating the discrimination between competing hypotheses relating to the causes of the roan antelope decline. As a novel perspective to this topic this study is intended to investigate the role of fire (time since last fire; fire frequency) in shaping the carbon metabolism of plants as manifested in non-structural carbohydrate levels and digestibility of selected forage species.

Investigation into the burning history of the four main blocks inside the roan enclosure revealed that the frequency of burning has not been as believed and intended. Times in years since last burn (as at end of 2007) were as follows: Block A (5.5 years), Block B (22,5 years), Block E (8 years) and Block F (19.5 years). Time periods since last burn outside of the enclosure are generally between 1 and 3 years. The roan enclosure situation therefore provides unique opportunities for investigating the effect of veld age on forage quality. The last grass sampling event is scheduled for February 2009. Once all data has been obtained, the effects of veld age on *inter alia* forage digestibility, nitrogen and TNC contents will be analyzed.

**LIVING ON THE EDGE: IN SEARCH OF PHYSIOLOGICAL AND BEHAVIOURAL DETERMINANT OF THE DISTRIBUTION BOUNDARY DYNAMICS OF TROPICAL UNGULATES IN SOUTH AFRICA**

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We postulate that the ability of ungulate species to maintain a positive energy balance with their respective environments determines their distribution limits. Thus, this study focuses primarily on how ungulate species of different body sizes, physiologically poorly adapted to the cold climates, cope with the cold environments. Ungulate species that evolved in tropical climates, with little seasonal variation in ambient temperature, and that expanded their range to the cold climates south of the tropic of Capricorn, are likely to be under physiological stress, particularly at high altitude.

## **SPATIAL AND TEMPORAL VEGETATION CHANGE ALONG A SECTION OF THE SABIE RIVER IN THE KRUGER NATIONAL PARK AFTER THE 2000 FLOOD**

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The high magnitude flood in February 2000 had a pronounced effect on the biophysical character of the Sabie River in the Kruger National Park (KNP), South Africa. In this study, an attempt was made to determine the impact of this large, infrequent flood on the vegetation by comparing post-flood data at three-year intervals with pre-flood vegetation data. Temporal as well as spatial shifts in the vegetation could be detected from results obtained from ordination techniques. After three years of recovery (post-flood data of 2003), the plant species composition was still largely different from the pre-flood vegetation state. Even after six years (post-flood data of 2006), little recovery towards the pre-flood state is evident. Monitoring post-flood vegetation dynamics, however revealed the directional shift in plant species composition towards a common onset of recovery. Spatially, the vegetation is not likely to recover to its original pre-flood state at specific localities due to the heterogenous imprint of biotic and abiotic patches that the flood has left. In the 1991-classified Dry Riparian Woodland locality, a directional shift towards a 'new' plant community is evident. The Riverbed community is exposed to stochastic intermediate flood events that intervenes with the recovery process and hence drive succession in many directions. Riparian Forest communities are closer related to their spatially post-flood counterparts, although recovery is not directional towards the pre-flood state. Continued monitoring of the Sabie River vegetation at three to four year intervals should reveal better understanding of the dynamics of this riparian ecosystem.

## **IMPACTS OF CLIMATE CHANGE AND VARIABILITY ON VEGETATION IN THE GREATER LIMPOPO TRANSFRONTIER PARK**

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The overall aim of this research is to clarify the degree to which temperature and rainfall variability determine vegetation changes in the Lowveld. The first objective is to establish the phenological parameters (for example, beginning and end of growing season, length of growing season and so on) of vegetation in the study area, and thereafter to relate these parameters to biophysical drivers such as available moisture and temperature using statistical methods, namely PCA and SOMs. The second objective is to make future projections of the vegetation phenology, assuming the biophysical drivers remain constant.

Preliminary findings are that there is no clear trend in the 18-year AVHRR-NDVI record of the study area that may be linked to temperature or moisture.

## **SPATIAL DEMOGRAPHY AND DIET OF ELEPHANTS: IMPLICATIONS FOR MANAGEMENT**

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As elephants are a major component of the Kruger National Park (KNP) ecosystem, the aim of this project is to understand herd's spatial demography and the feeding behaviour of male and female elephants in various age classes, to provide a spatially explicit predictive model of elephant impact across the study site. To date, 26 collars have been deployed in the Satara, Skukuza and Lower Sabie triangle.

Most of the collared herds showed a high degree of association within their complex. Important preliminary results are that, the ranges of the females extend across the proposed elephant management plan intervention boundaries, herds do not appear to be limited within their clan's fidelity and a number of herds incorporate private reserves within their ranges.

## **MONITORING OF GROWTH, RECRUITMENT AND ELEPHANT DAMAGE OF MARULA TREES INSIDE AND OUTSIDE THE NKUHLU AND MAKHOHLOLA ENCLOSURES IN THE KRUGER NATIONAL PARK**

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The objectives of the project are, to determine demographic parameters of the marula tree population, to determine the effect of damage, caused by either elephants or fire, on growth rate and mortality, to monitor the progression of events after a tree is damaged until it dies, and to determine the effect of geological origin of the soil on growth rate, recruitment and mortality in the marula population. In December 2005 ± 90 marula trees were selected; 60 at the Nkuhlu enclosure (10 for each treatment) and 30 at the buffalo enclosure (15 inside and 15 outside). These trees were marked, and their circumference was measured at the base and at breast height. They were also photographed from two fixed points. Furthermore, any damage was classified and photographed. In June 2006, 9 trees in the Nkuhlu enclosure and 10 in the buffalo enclosure were fitted with dendrobands.

During the December 2007 visit it appeared that 4 adult trees had died in the past year and one medium sized tree along the Orpen gravel road had been pulled over. The dendrobands were almost all in good condition, only two needed to be replaced and one was reset. It was decided to leave the recruitment experiment as the marking of the plots was inadequate, which made it impossible to delineate them reliably.

## BIOTIC SURVEYS FOR MYCETOZOANS IN KRUGER NATIONAL PARK

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Protostelids, dictyostelids (cellular slime molds) and myxomycetes (plasmodial slime molds) are three groups of eumycetozoans (the true slime molds) usually present and often abundant in terrestrial ecosystems. Eumycetozoans are amoeboid protists with a unique fruiting body structure for spore dissemination found in vegetated, terrestrial ecosystems. It is assumed they are integral in soil processes though without thorough knowledge of diversity and quantity of the species in an area, it is not possible to test ecological hypotheses. Very little is known about these organisms in South Africa, and Kruger National Park represented the first significant body of information about these organisms since the early 20<sup>th</sup> century.

Samples of substrate material were collected from seven sites within Kruger National Park in 2006. These samples of bark, dead leaf litter and soil from each site were collected for the purpose of isolating eumycetozoans (myxomycetes, dictyostelids and protostelids). To date, all samples have been processed for each of the three groups of organisms. Identification to species is ongoing and should be complete by early 2009. So far 32 species of myxomycetes have been identified from the locations sampled in Kruger National Park. The collections identified for dictyostelids from Kruger represent the first data on these organisms for South Africa. Subsequent data has since been collected in other regions of the country, but Kruger National Park boasts the highest species diversity (12 species) and species density (478 clones/g) for dictyostelid cellular slime molds of all the study sites examined. The smallest eumycetozoans (both in diversity and size) are the protostelids.

## **BIOLOGICAL CONTROL OF PARTHENIUM HYSTEROPHORUS, PRE- AND POST- RELEASE STUDIES**

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The study aims to evaluate aspects of parthenium growth and soil seed bank, and relative composition with other plant species both before and after the release of biocontrol agents. These data can then be utilized to quantitatively assess the agents' impact on the weed and evaluate their efficacy in a control programme. Although research has been conducted on aspects of the biology and ecology of parthenium in Australia, nothing is known of the plant's growth or soil seed bank in South Africa; this study aims to provide these data for selected sites in KNP.

## THE LIFE HISTORY, ENTOMOPHAGY AND CONSERVATION OF THE EMPEROR MOTHS, GYNANISA MAIA AND IMBRASIA BELINA IN THE KRUGER NATIONAL PARK AND NEIGHBOURING ENVIRONS

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The purpose of the project is to provide a better understanding of the life history of the selected Emperor Moths in order that more informed decisions may be made with respect to the impact of entomophagous use of this resource, the sustainability and agricultural potential thereof and conservation. The significant emergence of both species of Emperor Moths in December 2007 enabled data to be collected on the massive scale of the foraging effort of the caterpillars on the Mopane plants. Both species compete for resources on the same trees and the proportion of **Imbrasia belina** to **Gyanisa maia** caterpillars on the trees is significantly higher. The numbers of emerging caterpillars of the former species is so large that a significant number are not able to utilize the leaf resources adequately and prepare for and pupate successfully.

## LEPIDOPTERA OF THE AUGRABIES NATIONAL PARK

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A species list of the butterfly species of the Augrabies National Park is given based on fieldwork, more visits confirmed that an unexpectedly interesting butterfly fauna is present at the Augrabies National Park. The number of butterfly species on the checklist increased from 14 to 28.

An interesting degree of variation compared to specimens from further north east was observed in many of the more "common and widespread" species that were collected at Augrabies National Park. Individual variation suggests that care should be taken when the taxonomy of these species is considered. These variations are linked with some adaptations to the drier parts of Southern Africa and are probably important for the understanding of underlying biological and evolutionary processes (Terblanche & Taylor 2000). However, very interesting arid forms were found and are investigated taxonomically by G.A. Henning and R.F. Terblanche.

## **ELEPHANT (LOXODONTA AFRICANA) HOME RANGES IN SABI SAND RESERVE AND KRUGER NATIONAL PARK: A FIVE-YEAR SATELLITE TRACKING STUDY**

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During a five-year GPS satellite tracking study in Sabi Sand Reserve (SSR) and Kruger National Park (KNP) we monitored the daily movements of an elephant cow (*Loxodonta africana*) from September 2003 to August 2008. The study animal was confirmed to be part of a group of seven elephants therefore her position is representative of the matriarchal group. We found that the study animal did not use habitat randomly and confirmed strong seasonal fidelity to its summer and winter five-year home ranges. The cow's summer home range was in KNP in an area more than four times that of her SSR winter home range. She exhibited clear park habitation with up to three visits per year travelling via a well-defined northern or southern corridor. There was a positive correlation between the daily distance the elephant walked and minimum daily temperature and the elephant was significantly closer to rivers and artificial waterholes than would be expected if it were moving randomly in KNP and SSR. Transect lines established through the home ranges were surveyed to further understand the fine scale of the landscape and vegetation representative of the home ranges.

## **EVALUATING ECOLOGICAL INTEGRITY AND SOCIAL EQUITY IN NATIONAL PARKS: CASE STUDIES FROM CANADA AND SOUTH AFRICA**

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A primary goal has been the comparison of several case study national parks that are actively co-managed by government and local Indigenous and tribal groups to parks characterized by minimal co-management and involvement of Indigenous and tribal groups. Additionally, this work compares parks that exhibit many of the successes and challenges associated with designing and implementing ecological monitoring programs. In this study, a national park was considered to be successful at protecting ecological integrity if it achieved park management objectives in a manner that sustained biodiversity and ecosystem processes while abating threats. A park was considered to be equitable if it successfully addressed land tenure and access rights into the park (including unresolved historical loss of rights and those transgressed in the genesis of new parks), eased tensions and addressed concerns over local participation and decision-making authority in park governance, and resolved conflicts stemming from loss or change in local livelihoods.

Three of the parks in this study (Kluane, Pacific Rim, and Kruger) are effective at addressing both ecological and equity issues as they achieved ‘satisfactory’ ratings for both ecological integrity and equity. Kluane National Park Reserve (Canada) was the most balanced park in terms of ecological integrity and equity with virtually the same scores for these two factors. Kluane and Kruger had comprehensive management plans with explicit management objectives and readily available data sets for the analyses required in this study. Kluane and Kruger were ecologically effective overall.

## **EFFECTS OF POINT VERSUS PERIMETER IGNITIONS ON FIRE MOSAICS IN THE KRUGER NATIONAL PARK**

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A recent development in the use of fire in large conservation areas like the Kruger National Park, is the belief that controlled burns applied as point ignitions instead of perimeter ignitions (block burns) will promote the biodiversity of the overall ecosystem. This is because it is postulated that point ignitions will result in a greater fire mosaic developing in the areas being burnt because the fires take longer to burn and spread over the affected area. This in turn will result in greater diurnal variation in the temperature and humidity conditions leading to greater variation in fire intensity and its variable effects on the biotic components of the ecosystem. Diurnal changes in the speed and direction of the wind during the fires will also result in a greater mosaic of different types of fires (head, flank & back fires) with different effects on the flora and fauna in the burnt area thereby also promoting biodiversity in the ecosystem. At this stage all these perceived benefits of controlled burns applied as point ignitions are untested hypotheses and an urgent necessity exists to determine whether they do in fact result in a greater fire mosaic of different types and intensities of fires compared to areas burnt as perimeter ignitions.

## **A SURVEY OF THE COMPOSTING FUNGI IN MOPANE LANDSCAPE AND THE EFFECT OF DIFFERENT FIRE REGIMES ON THEIR SPECIES COMPOSITION**

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The Kruger National Park (KNP) has been conducting studies on different fire regimes for more than 50 years, but the effect of these fire regimes on fungal populations has not been studied before. A survey was conducted of fungi in the mopane landscape in the KNP by the Mycology Unit, ARC-PPRI. Twelve of the possible 14 fire regime plots at the experimental burning plot at Dzombi were sampled from October 2004 to October 2005. A total of 96 composite samples consisting of leaves and twigs, as well as plant debris and soil (32 of each sample type) were collected during five sampling trips to the park. Each composite sample consisted of five sub-samples each collected surrounding a different mopane tree. All samples were plated out onto potato carrot agar (PCA), PCA amended with antibiotics, selective *Fusarium* agar and moist chambers. All soil samples were plated out directly, as well as serial dilutions made. Plant material (a combination of twigs and leaves) and debris were plated out directly as well as surface sterilized. All fungal growth was recorded and selected isolates purified before being preserved at ultra low temperature. At present 1310 purified fungal cultures were stored, of which 306 cultures were deposited in the living culture collection of South African National Collection of Fungi (PPRI). A checklist of 74 fungal species or genera is provided. Total DNA extracted from 26 soil samples was used to determine the population dynamics of all the soil samples by means of the denaturing gradient gel electrophoresis technique. The cluster analysis of the 18S gene resulted in a profile representing the prokaryotic populations present in the different samples. The profiles for all 26 samples are similar with no differences between the enclosure plots, or the pre and post burning samples. The cluster analysis of the internal spacer region (ITS) resulted in a profile representing the eukaryotic populations present in the different samples. The three main clusters represent no clear distinction among the enclosure plots, or the pre and post burning samples, although different statistical analysis were done.

## **THE INFLUENCE OF STREAM ORDER ON RIPARIAN BIODIVERSITY: THE LINKS BETWEEN COMPOSITIONAL, FUNCTIONAL AND STRUCTURAL BIODIVERSITY**

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The study was initiated to investigate compositional and structural diversity along rivers in south-western Kruger National Park ranging from first stream order (small rivers) to seventh stream order (large rivers). Functional diversity was not considered due to time constraints. The two main aims of the study are: 1) determine how compositional diversity of woody plant species and birds changes along a stream order gradient, and 2) determine how structural diversity of woody plant species and birds changes along a stream order gradient.

Overall both the species diversity and the community composition analyses for woody plant species indicate a contrast between the perennial 7<sup>th</sup> order river and the seasonal 1<sup>st</sup> through 5<sup>th</sup> order rivers. This is due in part to the large number of “locally endemic” species (species recorded in only one stream order) found within the 7<sup>th</sup> order, but more importantly it is brought about by the varying abundance of commonly encountered species. Unlike woody plants, bird species diversity remains similar along the entire stream order gradient from 1<sup>st</sup> through to 7<sup>th</sup> order rivers. However, like woody plants, there is differentiation between the orders in terms of their community composition. The 7<sup>th</sup> order river is the most distinct, while the 4<sup>th</sup> and 5<sup>th</sup> as well as the 1<sup>st</sup> and 2<sup>nd</sup> order rivers also group together.

## **UNESCO AND ITS AGENCIES' IMPACT ON CULTURAL POLICY FRAMEWORKS IN AFRICA: A STUDY OF THE MAPUNGUBWE WORLD HERITAGE SITE IN SOUTH AFRICA**

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UNESCO's World Heritage Convention of 1972 has set the standard for the evaluation, preservation and conservation of World Heritage Sites (WHS) globally. The role and function of UNESCO in the cultural heritage sector in Africa, in particular cannot be denied. However, the World Heritage Convention (WHC) policy requirements for African States that are parties to the Convention, presents challenges in terms of implementation. This is due in most cases, to lack of infrastructure, deficient national policy structures, poor legislation, bad management and poor implementation. This is particularly the case in developing countries where governments are grappling with socio-economic and political challenges. Questions are raised about who has the right to define heritage, and what kinds of parameters are used to measure World Heritage of "universal" value. Is it appropriate for UNESCO to "impose" a global cultural policy on the world? What then are the implications for African sites for being listed as World Heritage, and what are their chances of competing in the global cultural arena based on the challenges mentioned above?

This research report, through a study of the Mapungubwe Cultural Landscape in the Limpopo Province of South Africa, attempts to grapple with aspects of the questions raised above, and seeks to illustrate the challenges of managing a World Heritage Site. It highlights the gaps between WHC requirements, national cultural policy legislation, infrastructural and human resource incapacity, and implementation by the management at the WHS.

## **THE SOUTHERN AFRICAN BUTTERFLY CONSERVATION ASSESSMENT (SABCA)**

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SABCA is a four year project, aimed at determining the distribution of butterflies in the atlas region (South Africa, Lesotho and Swaziland) and increasing the understanding of the region's butterfly biodiversity, thereby contributing to effective conservation planning and management. Field surveys are conducted by the SABCA field survey team consisting of accredited member of the Lepidopterists' Society of Africa. Surveys will continue to be conducted in the SANParks listed above for the duration of SABCA, in order to take into account seasonal changes in butterfly diversity and to conduct surveys in NPs not surveyed yet.

## THE SPOTTED HYAENA: A MODEL SYSTEM TO STUDY RESISTANCE TO TUBERCULOSIS

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This project is aimed at using naturally resistant animal models to study resistance to tuberculosis. The hyaena is hypothesized to be such an animal. In order to establish some technologies, we are also using the domestic dog as a surrogate. We have been able to establish macrophage cell cultures from domestic dogs. However, this is a difficult process and we are not able to establish sufficient cells to do what we originally envisaged. This means that macrophage culture and infection models in hyaenas will not be possible at present. However, we have been able to establish a blood stimulation model in dogs and Elisa plate assay and FACS analysis for cytokines in dogs. We have also established a speciation technique for Mycobacteria so that we can determine exactly which species infects any given animal. Some hyaena blood samples were taken and stimulated. These samples were transferred to our labs for assay.

We have established that dogs (also apparently a resistant animal) can be infected by M tuberculosis, and that we can detect this by blood stimulation and assay. FACS analysis is suggesting some immune parameters which may provide clues to resistance. This will have to be further investigated in more dogs and in hyaenas if the reagents used and available can be transferred to the hyaena model and if logistics allow it.

# **A HISTORICAL AND ARCHAEOLOGICAL INVESTIGATION OF THE CULTURAL REMAINS OF THE DIFFERENT OUTPOSTS OF THE STEINAECKER'S HORSE MILITARY UNIT IN THE KRUGER NATIONAL PARK**

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The research was undertaken to show a connection between historical information and the archaeological evidence with regards to different outposts of Steinaecker's Horse. During 2008 it focussed on the site at Ngotso Mouth. The archaeological research for 2008 focussed on the Ngotso Mouth site at the confluence between the Ngotso and Olifants River, close to the Balule rest camp. Very little evidence regarding this site is found in historical sources. The famous game ranger and member of Steinaecker's Horse, Harry Wolhuter, mentions that he camped alongside a river on his way to some of the outposts of Steinaecker's Horse in the north. He named the river Ngotso after one of the indigenous people who guided them to the Olifants River. Pienaar also makes mention of an outpost close to the Olifants River.

During 2008 five excavations were conducted. These were all on different refuse middens. The excavated artefacts which are still being analysed, will provide valuable information on the way of life of the unit and their daily activities. Preliminary indications are that the excavated material is very similar to those at The Letaba and Sabi Bridge sites and that it includes typical military artefacts such as ammunition, bully beef tins and uniform buttons.

Other artefacts such as glass beads and pottery are definitely linked to the indigenous people. As is the case with the other two mentioned sites it indicates that the members of Steinaecker's Horse stayed with these people and that they may have been used for military activities such as sentry duty and scouting or other domestic tasks. This undoubtedly gives information on the participation and role of black people on the site especially in connection with their lifestyle and their position regarding the Anglo-Boer War as a whole.

## THE ECOLOGY AND DISTRIBUTION OF THE SOUTHERN BARRED MINNOW (*OPSARIDIUM PERINGUEYI*) IN SOUTHERN AFRICAN RIVER SYSTEMS

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The aim of the research is to establish the seasonal abundance, establish if there is any migratory patterns and to collect genetic material for further analysis. No *O.peringueyi* was sampled for the duration of the excursions into KNP. But was found at the Hoxani Weir, which is in close proximity to the KNP border. It was sampled in conjunction with *Amphilius uranoscopus* at Hoxani Weir. It may be worth to note that *A. uranoscopus* was also not present during the sampling excursions within KNP. Overall sampling was highly productive when compared to other sites sampled on the Sabie outside KNP. A large array of species in relative high abundance was found, with exception to *Serranochromis meridianus* of which only one specimen was caught.

## **SPATIAL AND SEASONAL RESOURCE USE BY TREES AND GRASSES IN A MESIC SAVANNA**

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This study focuses on two major environmental gradients in savannas: water and nutrients. The aim of this research is to provide more insight in the functioning of savanna ecosystems, by assessing the water use and nutrient uptake of trees and (to a lesser extent) grasses, using a multi-faceted comparative approach.

Studying tree-grass interactions is of great importance for the understanding of savanna ecosystem functioning. The results of the current study are anticipated to contribute to the understanding of the mechanisms that determine the co-occurrence of trees and grasses on the savanna.

Knowledge of the physiology of woody plants and grasses is of paramount importance, as diversity in physiological traits reflects differences in resource utilization. The understanding of resource use is a prerequisite for the understanding of inter life-form coexistence in a natural, heterogeneous environment. Coexistence of trees and grasses in savannas may be possible if trees and grasses occupy different niches when exploiting limiting resources such as water and nutrients. Walter (1971) was the first to propose that trees and grasses compete for water in the upper soil profiles, where grasses are the better competitors, whereas trees can persist in the system because they have sole access to water in deeper soil layers.

Another competition-based hypothesis for tree-grass coexistence, which has as yet not been tested, was suggested by Scholes and Archer (1997). It developed from the observation that some drought-deciduous tree species start forming leaves before the first rains of the growing season. These drought-deciduous trees discard their leaves long after the last rain shower in the dry period. This way, trees are able to extend their growing season and thus have exclusive access to resources early and late in the growing season. In this scenario, grasses must be the better competitors in the time that they have their peak flush if they are to persist in the system. This phenomenon has been interpreted as a strategy of trees to avoid competition for resources with grasses, making co-existence of grasses and trees possible (Scholes and Archer 1997).

## REGIONAL DESCRIPTION OF THE GROUNDWATER CHEMISTRY OF THE KRUGER NATIONAL PARK

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The Kruger National Park (KNP) has adopted a Strategic Adaptive Management (SAM) program with clear ecosystem management goals based on environmental indicators and their thresholds of potential concern (TPC). Groundwater has been recognized as one of the environmental indicators that needs to be monitored and for which TPCs will have to be developed in the park. While the Department of Water Affairs and Forestry (DWAF) assists the KNP with the groundwater quantity TPCs and monitoring, the current project will assist the KNP with the groundwater quality TPCs by providing a regional characterization of the groundwater chemistry in the park (using National Groundwater Database and own data). Another emphasis of the project is to train KNP staff in groundwater sampling according to SANS/SABS standards.

Seven regional groundwater types were identified for Kruger, based on the major underlying geology. Na (and to a lesser extent Mg) were the dominant cation and HCO<sub>3</sub> was the dominant anion present in the water. The seven groundwater types can be used as stratification criteria for future groundwater monitoring efforts and the setting of TPCs (this stratification can be seen as “groundwater landscapes” and is a useful stratification criterion both for groundwater quality and for groundwater quantity).

## **MULTI-SCALE AND MULTI-TECHNIQUE APPROACHES FOR MEASURING CARBON EMISSION RATES FROM SAVANNAH FIRES IN KRUGER NATIONAL PARK, SOUTH AFRICA**

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Eight prescribed fires within KNP were studied in August 2007 and November 2008. The fires focused on were those in the Pretoriuskop and Skukuza areas undertaken by Navashni Govender and her team as part of the experimental burn plot trial initiated in 1954. A broad suite of *in-situ* and remote sensing techniques were used to measure the active fire environment during the burns, together with simultaneous high temporal resolution measurements from a dedicated weather station, and instantaneous observations from the MODIS instrument onboard the over-passing Terra and Aqua satellites. Pre- and post-burn fuel characteristics were collected at each fire. Development of retrieval methods for deriving the required information from the remote sensing data, together with subsequent data processing and analysis, is ongoing.

# **TOURISM POLICY AND BIODIVERSITY CONSERVATION AND MANAGEMENT: A CASE STUDY OF KRUGER NATIONAL PARK, SOUTH AFRICA**

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The outline of the thesis. Chapter 2 traces some aspects of the transformation of South African wildlife management during the 1930s up to present and how these changes impacted on tourism policy and biodiversity conservation initiatives. Chapter 3 provides insight on the creation and the zoning of the Kruger National Park. The chapter also presents the administrative management changes in the pre- and postapartheid era and the implications on tourism, biodiversity conservation and management. Chapter 4 gives an overview on tourism, water provision and elephant management policies in relation to their formulation and implementation over time. The chapter takes an in-depth look into the environmental impacts of each of the three policies and to what extent Park management addresses the environmental concerns. Chapter 5 unpacks the issues that build on the notion of environmental policy integration approach and how should institutions in the policy-making arena be shaped to advance it.

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