SAVE THE ELEPHANTS

US Fish and Wildlife Service Assistance Award –Final Performance Report

April 2013

Project Title:	Transboundary elephant research programme within Great Limpopo Transfrontier Park, South Africa
Assistance award Number:	96200-1-G129
Organisation name:	Save the Elephants-South Africa
Project officers:	Dr. Michelle Henley
Project start date:	18 July 2011
Project end date:	30 January 2013
Reporting period:	2003 – 2013 (Depending on the dataset under consideration)

2. NARRATIVE TEXT

a) Executive summary

Out main purpose is to understand how and why elephants move from core conservation areas such as the Kruger National Park (KNP) into peripheral areas and the resulting ecological and socio-economic implications of these movements. The Associated Private Nature Reserves (APNR) to the west, the Makuleke Community Area to the north together with Limpopo National Park (LNP) to the east of the KNP represents important unfenced areas along which elephants can establish historical migration routes. Ultimately, our data will lead to a greater understanding of the spatial and temporal interactions between wildlife and human activities. Conflict mitigation will depend on understanding where, when and why elephants move across the landscape, enabling careful land planning to minimize conflict and maximize the potential economic benefits of charismatic wildlife to people. This information will contribute towards improving our knowledge of the ecological processes that will propagate the coexistence of elephants, trees and people.

The project to the north, where nine of the original 12 elephants that were first collared in 2008 have been recollared in 2012, will continue to provide data that can be used to design a biologically relevant corridor that will link the Gonarezhou National Park in Zimbabwe with the KNP. The results of this project, funded by the USFWS (96200-9-G251) have been detailed in the Final Report. The project to the East, in a recent collaboration with SANParks and other interested parties will help define how underlying geology at landscape level may be driving genetic differentiation within the Kruger elephant population. The project in the west is focused on the movements and range use patterns of elephants at landscape scale and to establish the drivers behind the patterns observed. Hence the ongoing elephant identification study, the telemetry study and the vegetation study will provide valuable information in the long term which will contribute towards managing elephants in accordance with the Draft National Norms and Standards for the Management of Elephants in South Africa (DEAT 2007).

Specific anticipated outputs from the continuation of the activities in the APNR include:

- Establishment of long term monitoring sites to provide information on elephant landscape preference
- A comparison between the mortality rates of a population susceptible to poaching (East Africa) compared to a population subjected to commercial hunting (APNR) and potential poaching in future.
- A database on the availability of large tusked bulls and recruitment rates of potential large tuskers into this segment of the population
- Assessment of societal distribution, by means of questionnaires, of a segment of human value systems (private landowners, share block owners and managers) that underlie changes brought about by either human or elephant impact.
- An understanding of how different land use practises (tourism and hunting) can affect elephant movements (i.e. the construction of fear landscape maps)
- To establish rates of change in important landscape features (large trees of specific species as indicators) over time.
- Information on the predictability and assessment of the vulnerability of large trees in certain areas.
- Assessment of the vulnerability of large trees used as nesting sites by Southern Ground Hornbills, raptors and vultures.
- Evaluation of large tree protection methods as a management mitigation method to protect the aesthetic features of the landscape and ensure the availability of nesting sites for large tree nesting birds.

b) Main location of the project work

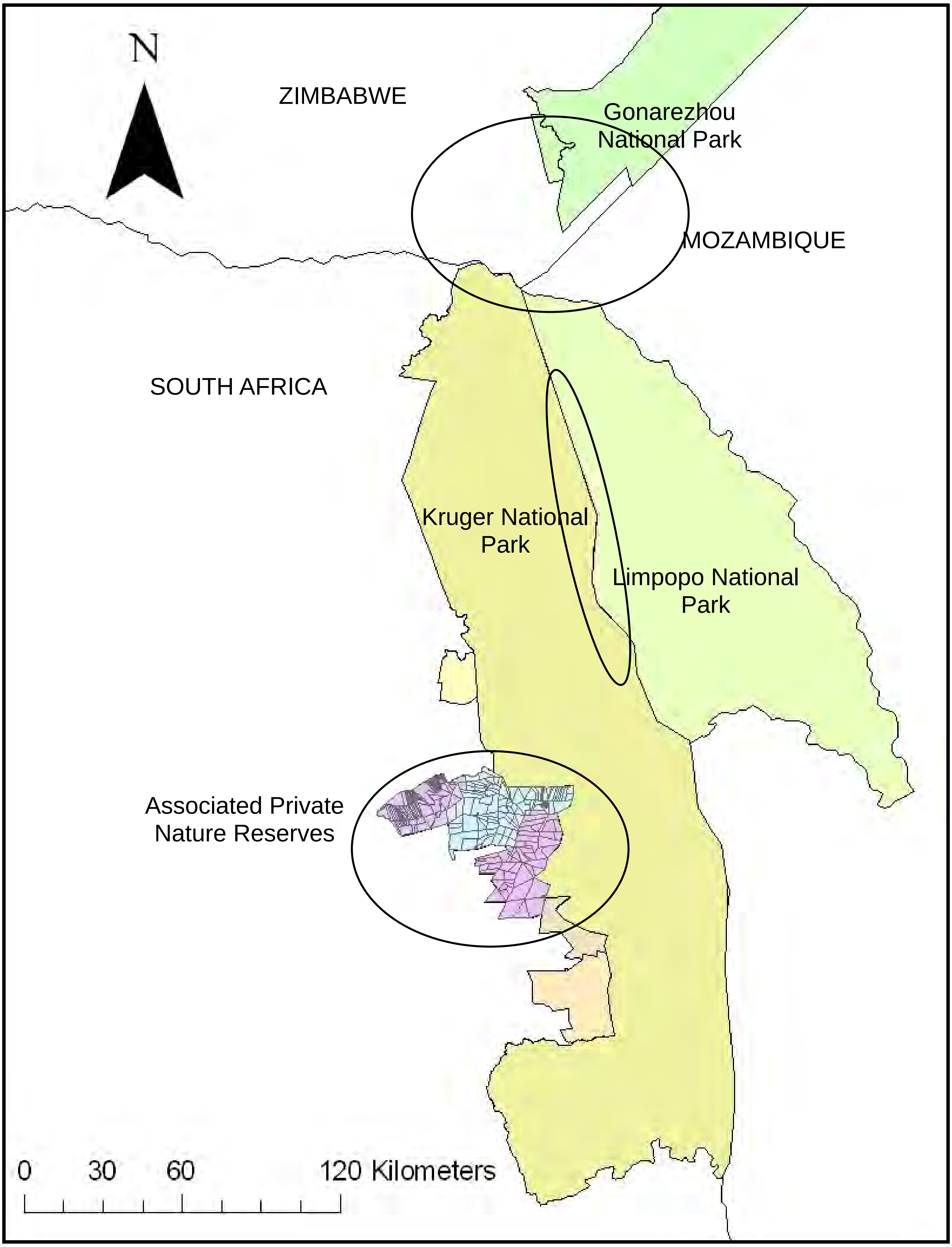


Figure 1: Great Limpopo Transfrontier Park with the Associated Private Nature Reserves in the west, Gonarezhou to the north and Limpopo National Park to the east of the Kruger

National Park. The encircled areas indicate where GPS satellite/GMS collars have been deployed.

c) Activities and outcomes to achieve objectives

The ***objectives*** of this research project were:

1. To conduct research into how habitat resources, the need for safety and the social presence of other elephants influence observed patterns in elephant movements.
2. To develop a spatial predictive model that defines elephant intensity of use across the landscape.
3. To determine how different land use practises drive perceptions on the conservation significance of elephants.
4. To evaluate the consumptive use practices in the Associated Private Nature Reserves (APNR) after assessing the demographic profile of the population and their perception of risk.
5. To understand the movements and social importance of the remaining big tusked bulls within the Great Limpopo Transfrontier Park (GLTP).
6. Relate elephant occurrence to their impact on the tall tree component of the vegetation as quantified by the type and intensity of use
7. Determine the level of sensitivity between selected large tree-nesting birds and elephant impacts on their nesting trees
8. To measure the efficacy of management interventions (wire netting of individual large trees) aimed at reducing elephant impact to the large tree component.

We applied for USFWS funding for part of our core funding needs to be met in order to continue our long-term monitoring programme of elephants and trees at the western study site as well for the continuation of the elephant identification study within the Makuleke. In order to meet the above mentioned objectives, four distinct datasets are being used:
(1) Elephant ID study is used to address objective 1, 2, 4 and 5
(2) Questionnaire surveys were used to address objective 3.
(3) The GPS telemetry study is used to address objective 1,2, 4 and 5.
(4) The large tree monitoring project is used to address objective 1,2,6,7 and 8.

Study area and methods

The overall study area can best be defined as the total area used by elephants fitted with Geographic Positioning System (GPS) telemetry devices within the Great Limpopo Transfrontier Conservation Park (GLTP). The GLTP covers approximately 35,000km^2 and includes the Associated Private Nature Reserves (APNR) and the Kruger National Park (KNP) in South Africa, Mozambique’s Limpopo National Park and Zimbabwe’s Gonarezhou National Park. The APNR is located to the east of the Drakensburg escarpment on the western boundary of the KNP and consists of the Klaserie, Timbavati, Umbabat and Balule Private Nature Reserves (24º 03’- 24º 33’ S; 30º 49’ – 31º 29’E), comprising approximately 1,825 km^2. The climate is semi-arid with a mean annual rainfall of less than 600mm; as in the KNP, rainfall is known to increase from east to west and from north to south (Gertenbach 1980, Venter & Gertenbach 1986). Acocks (1975) broadly described the vegetation type as *Acacia nigrescens-Sclerocarya birrea* savannah with *Combretum apiculatum, Colophospermum mopane* and *Grewia* species representing other dominant plant species (De Villiers 1994). The KNP is situated between 22°20’ – 25°32’S and 30°53’ – 32°02’E and covers an area of 18,992 km^2. The various ecotypes of the KNP are based on differing environmental conditions, including geology, climate and plant composition (Gertenbach 1980, Venter & Gertenbach 1986, Venter et al. 2003). Six

elephant bulls were monitored continuously from June 2007 to June 2008 in the eastern regions of the KNP, in a study area of approximately 5500 km^2 (Ganswindt et al 20010a, Ganswindt et al. 2010b). The vegetation in this region consists predominately of open shrub to fairly dense bush savannah and partly open to moderately dense tree savannah (Venter et al. 2003). Rainfall in this region averaged 450–500 mm/year (Zambatis 2003).
The Pafuri land system represents 4.7% of the KNP (92 423 ha) and although highly variable in geology, soils and vegetation, the six different land systems are commonly grouped together based on their generally high relief (Venter 1990). Broadly, the vegetation can be classified into Sandveld communities to the west, mixed Bushwillow/Mopane Bush Savanna to the north and east, and Mopane Shrub Savanna to the south east. The alluvial floodplains of the Luvuvhu and Limpopo rivers are dominated by tall and dense *Acacia albida / Ficus sycomorus / Xanthocercis zambesiaca* riverine forest with *Acacia xanthophloea* often dominating the edges of pans (Gertenbach 1983, Venter 1990). Overall, the generalized vegetation type can be described as *Colophospermum mopane*/*Commiphora gladulosa*/*Adansonia digitata* tree savanna (Venter & Gertenbach 1986). The Pafuri region is known as one of the driest landscapes in the KNP with an average annual rainfall of 440mm (Gertenbach 1980, Gertenbach 1983, Venter & Gertenbach 1986). Extremely high temperatures of up to 47°C can be experienced during the summer months.

<u>ID study</u>
Individual identification records of sighted animals (bulls and cows) were recorded by collecting detailed photographs within the APNR and from guides operating in the Makuleke Concession area. The photographs are used to make drawings based on unique patterns of tears, nicks, holes and veins in the ears. These techniques have been well established in the past (see Douglas-Hamilton 1972) and have recently proved useful to estimate demographic parameters (Goswami *et al.* 2007, Morley & van Aarde 2007). As with reaction indices of study animals, the presence or absence of musth in bulls was collected according to standard procedures used by STE-SA (presence or absence of temporal gland secretion, temporal gland swelling and the dribbling of urine) and described in earlier applications to the USFWS.

<u>Questionnaire surveys</u>
Identical questionnaires were distributed to landowners, shareblock holders and managers (reserves, shareblocks and lodges) within the APNR. The questionnaire was available in either English or Afrikaans and was circulated via email in 2003, 2007 and 2012. Respondents had up to three months to respond and could either post, hand deliver or return the questionnaire via email. The formulated questions were initially used to identify which woody plant species need to be monitored for elephant impact based on the concerns raised by landowners and managers alike. The questionnaires were also used to gather information on the perceptions of various parties in relation to:

- vegetation monitoring and changes in the vegetation structure (bush encroachment and tall tree loss);
- elephant research, water-point closure and the removal of the western boundary fence;
- trophy hunting, green hunting and the culling of elephants; and
- ranking of various plant species that were found to constitute large dietary proportions of both bull and cow groups of elephants within the APNR (Greyling 2004).

In 2012 an additional survey was circulated simultaneously to not only the same affected parties of the APNR but also to tourists visiting the lodges within the Reserves. The additional questionnaire aimed to understand the perceptions of the different interest groups (managers, residents and tourist) towards elephants and large trees as well as towards the available management options concerning the conservation of elephants within South Africa. Questions were formulated to specifically contribute towards the ongoing large tree and elephant tracking project within the APNR and will form part of a B.Sc. (Hons) project conducted by Adam Edge.

General statistics of questionnaires

For the questionnaire distributed by Save the Elephants – South Africa (STE-SA), a total of 76, 131 and 89 questionnaires were returned in 2003, 2008 and 2012 respectively. Questionnaire responses from resident stake holders of the APNR were grouped into those received from landowners, shareblock owners and managers of the Reserves, shareblocks or lodges respectively. For the questionnaire distributed by Western Kentucky University (WKU) in 2012, an additional questionnaire which was distributed together with the STE-SA questionnaire to the same affected parties within the APNR, 83 were returned. In addition 138 questionnaires were returned from tourists from Kings Camp, Tanda Tula Safari Camp, Umlani Bush Camp and Rock Fig in the Timbavati Private Nature Reserve. In Balule Private Nature Reserve, tourist respondents came from Tora Yaka Bush lodge, Tremisana Game Lodge, Ezulweni River lodge and Naledi Enkoveni. All tourist surveys were distributed in hard copy by the lodge managers and collected over time. In general we had more than a 20% return on the questionnaires that were distributed to residents via email. However, if one includes that Shareblock managers may have distributed the questionnaire to all their members or if all shareblock members were to have responded to questionnaires surveys posted on the respective websites, then returns may have dropped to just over 10% for each of the years. The general statistic relating to the 2012 questionnaires are depicted in Table 1.

Table 1 Summary of the number of questionnaires distributed and returned to STE-SA and WKU respectively in 2012.

Sent/Recieved			
	STE-SA	WKU	
	Resident	Resident	Tourist
Sent (known)	350	350	485
Sent (presumed	644	644	
Recieved	89	83	138
Return %	25.43% 13.82%	23.71% 12.89%	28.45%

Most resident respondents were South African citizens, males and retired (over 60 years of age). In contrast, most tourist respondents were non-South Africans, females and younger than 60 years of age (Table 2).

Table 2 The nationality, Gender and age of resident and tourist respondents of both the STE-SA and WKU questionnaire

Demographic						
	Nationality		Gender		Age	
	SA	Non-SA	Male	Female	Under 50	50 and Over
Resident	66	18	77	15	31	53
Tourist	36	101	64	75	73	65

For the resident respondents of both the STE-SA and WKU questionnaire, the majority of the resident respondents to both the STE-SA and WKU questionnaire were resident for more than five years but less than 20 years but infrequent visitors to the APNR (Table 3&4). Tourists were mainly return visitors to South Africa (Table 4).

Table 3 Number of resident respondents that were either landowners, Shareblock owners or managers in the APNR, including the number of years of residency or ownership in the area.

Residency						
Resident Position				Years of Residency		
Landowner	Shareblock	Manager	Other	5 and Under	6-20	21+
46	30	13	2	17	40	33

Table 4 Residents number of visits to the APNR in contrast with those of tourists based at the lodges when questionnaires were distributed by WKU.

'Visits'			
	Permanent / SA Resident	Been to SA before	First time to SA
Resident	21	33	36
Tourist	37	86	9

With the questionnaire surveys, Chi square tests were used to test for differences between categories (differences in opinions between years and differences between resident/manager/tourist types within a year for each of the questions that were asked). Small frequencies within certain categories of the questionnaire prevented the use of Chi square tests. We here report on the percentage of respondents which agreed, disagreed or were neutral in their opinions on:

- vegetation monitoring and changes in the vegetation structure (bush encroachment and tall tree loss)
- ranking of various plant species that were found to constitute large dietary proportions of both bull and cow group of elephants (Greyling 2004).

Prior to analyses, questionnaires were grouped into those received from landowners and shareblock owners (seen as residents), managers of reserves, lodges or shareblocks and tourists. Shareblock owners or managers were either from Olifants River-, Olifants North Game Reserve, Ingwelala, Ntsiri or Ndlophu.

GPS telemetry study

Our tracking data, collected over more than a decade, represents a long-term study focused on understanding the spatial and temporal variation in landscape use by elephants as they move across core conservation areas such as the KNP to the North (Zimbabwe), the East (LNP in Mocambique) and the West (APNR). We have obtained an improved understanding of elephant ranging behaviour through the collaring and recollaring of 57 elephants during 88 collaring operations in the western, eastern and northern regions of the KNP which was first initiated in 1998. Elephant movements and range use patterns will be determined in future by replacing GPS-satellite or GPS/GSM collars on existing study animals as they run down and collars are sponsored by interested and affected parties. The collars were manufactured by African Wildlife Tracking (AWT), a South African company that has manufactured all the collars that STE-SA has deployed. The immobilization of study animals within the KNP was done by Dr. Markus Hofmeyr or Dr. Peter Buss using the SANParks pilot and helicopter. The ground crew comprised of the local KNP Section Ranger and their field staff for security back-up Elephant collars that were replaced in the Protected Areas surrounding the KNP, were primarily conducted by Dr. Cobus Raath (who has extensive experience with immobilising elephants after working in the KNP for 12 years) or his protégée from Wildlifevets.com The ground crew was made up of the relevant Warden/Manager and his field staff for security back-up. STE-SA fitted the collars. All people involved in recollaring operations represented a very experienced team.

All collaring operations, both past and anticipated, will be conducted according to standard procedures as practiced within the Kruger National Park (SANParks 2011). During collaring operations all study animals were darted by a veterinarian qualified to administer the chemical agents and perform the necessary veterinary procedures. The majority of collaring operations in the past have taken place from a helicopter flown by a pilot experienced in wildlife capture or related procedures as darting elephants on foot or from a vehicle can be potentially more dangerous. The study animal, whether a bull or cow, was darted in the large muscle groups at right angles to the body surface to ensure deep intramuscular injection of the hindquarters, back or shoulders. A30-80 was administered as a mixture with M99 with the dose dependent on the age, sex and body condition of the animal. Azaperone was be added to reduce hypertension while the addition of hyaluronidase to the drug cocktail assisted with drug absorption. The drugs were administered from a dart gun kept at a shooting range of 30-40 meters from the study animal. The darted animal was separated by the helicopter from the associating family group or bull group during collaring operations and after delivery of the drug. The induction times usually averaged 10 minutes. Induced animals slowed their pace under the effects of the drug, eventually toppling over. The immobilized animal was fitted with a collar, ensuring that the collar was not fitted too tightly especially in younger study animals. Steel cable passing through an iron rod was used to pull the collar between the ear and the neck without damaging the cartilage in the ear. Morphometric measurements were taken of the back length, shoulder height, feet circumference and diameter. Blood and tail hair samples were collected from the immobilized animals for DNA and carbon isotope analyses of short-term dietary changes, respectively. Dental impressions were taken if the material was available, based on the methods of Rasmussen et.al. (2005). We used Speedex Putty as silicone-based impression material together with Universal Activator from Coltène/Whaledent AG (Coltène, Altstsätten, Switzerland). Age estimates (accurate within ± 3 years) could then be made from all molar progressions as described by (Laws 1966, Sikes 1971, Jachmann 1988, Manspeizer & Delellegn 1992, Lee et. al 2011). In cases where the immobilized animal did not spontaneously roll onto its side (lateral recumbency) or could not be assisted by the ground crew to do so, thereby remaining in an upright 'sitting' position (sternal recumbency), collars were fitted as quickly as possible and the full antidote administered to ensure the well-being of the elephant as the bulk of the digestive tract and the shape of the thoracic cavity can lead to respiratory distress. As elephants are obligate nasal breathers the trunk was kept in a straight position and a twig inserted into the external opening of the trunk to ensure unobstructed breathing. During collaring operations the elephant's ears were folded over the eyes to protect them from harsh sunlight, dust and trauma. The pulse rate (40-50 beats per minute) and respiratory function (6-8 breaths per minute in adults) were monitored. Body temperature was kept below 41°C by throwing jerry cans of water over the ears and body at regular intervals. The antidote was administered in one of the blood vessels in the ear and consisted of a naltrexone in combination with diprenorphine. The antidote usually took effect 3-5 minutes after being administered whereupon the animal got to its feet and slowly re-orientated itself, usually in the direction of the other animals from which it was separated during the collaring operation. Identifications photos of all collared individuals were collected prior to, during and after collaring operations to ensure that the study animals could be identified elsewhere by relevant parties. The length of the functionality of each of the deployed collars is listed in Table 5.

The telemetry data on each study animal consisted of a series spatial locations, ordered in time, with unique time periods, or intervals, between each pair of consecutive locations.

Table 5: Collar codes and deployment dates for all animals collared since 2003. Rows shaded green refer to collars that are active within the APNR while yellow rows refer to active collars within the northern study site (Pafuri)

Collar type	Animal id	Name	Sex	Collaring location	Deployment time (GMT)	Data_starts (GMT)	Data_stops (GMT)
Satellite	TKM05	Mac	Male	Timbavati-Klaserie PNR	2003-08-20 16:15:00	2003-08-20 17:50:00	2005-04-25 02:05:45
Satellite	TKM06	Classic	Male	Timbavati-Klaserie PNR	2004-05-19 10:53:00	2004-05-24 04:09:28	2006-06-16 06:41:00
Satellite	TKF01	Diney	Female	Timbavati-Klaserie PNR	2004-05-19 08:49:00	2004-05-24 03:18:24	2006-06-22 07:18:55
Satellite	TKF02	Joan	Female	Timbavati-Klaserie PNR	2004-11-02 06:00:00	2004-11-02 07:00:03	2006-10-23 11:30:16
Satellite	TKM07	Al	Male	Timbavati-Klaserie PNR	2004-11-02 09:02:00	2004-11-02 10:16:18	2007-05-20 15:14:06
Satellite	TKM08	Benjamin	Male	Timbavati-Klaserie PNR	2004-11-02 08:04:00	2004-11-02 08:04:00	2005-06-23 13:54:58
GSM	TKF03	Mandy	Female	Timbavati-Klaserie PNR	2005-05-16 10:00:00	2005-05-16 13:11:19	2009-01-24 04:11:30
Satellite	TKM05	Mac	Male	Timbavati-Klaserie PNR	2005-05-16 06:50:00	2005-05-16 12:46:53	2007-02-15 12:46:00
GSM	TKM09	General	Male	Timbavati-Klaserie PNR	2005-05-16 08:43:00	2005-05-16 13:11:23	2011-07-05 04:44:10
GSM	TKM10	Soshangane	Male	Timbavati-Klaserie PNR	2005-10-20 05:45:00	2005-10-20 10:33:49	2009-01-24 06:00:50
GSM	TKF04	Umbabat	Female	Timbavati-Klaserie PNR	2005-10-20 06:50:00	2005-10-20 07:54:00	2008-01-17 08:56:00
GSM	TKM11	Brazen	Male	Timbavati-Klaserie PNR	2005-10-20 09:10:00	2005-10-20 12:54:19	2007-03-08 05:59:38
GSM	TKM06	Classic	Male	Timbavati-Klaserie PNR	2006-06-16 07:00:00	2006-06-16 10:00:49	2011-02-15 20:00:26
GSM	TKF01	Diney	Female	Timbavati-Klaserie PNR	2006-06-22 10:43:00	2006-06-22 14:00:00	2006-08-14 22:00:00
GSM	TKM15	Striburus	Male	Timbavati-Klaserie PNR	2006-06-22 08:43:00	2006-06-22 09:01:00	2010-10-09 16:00:00
GSM	TKM18	Everest	Male	Timbavati-Klaserie PNR	2006-09-27 11:30:00	2006-09-27 12:00:00	2008-07-29 07:00:00
GSM	TKM17	Caughley	Male	Timbavati-Klaserie PNR	2006-09-27 09:55:00	2006-09-27 14:00:00	2011-01-28 05:03:00
GSM	TKM16	Tussle	Male	Timbavati-Klaserie PNR	2006-09-27 09:00:00	2006-09-27 09:03:00	2011-01-30 14:00:00
GSM	TKF02	Joan	Female	Timbavati-Klaserie PNR	2006-10-24 05:55:00	2006-10-24 06:01:00	still deployed
GSM	TKF08	Lapajuma	Female	Timbavati-Klaserie PNR	2006-10-24 07:30:00	2006-10-24 08:00:00	2011-02-16 07:00:00
GSM	TKM19	Gower	Male	Timbavati-Klaserie PNR	2006-10-24 09:00:00	2006-10-24 10:00:00	2011-02-02 22:00:00
GSM	TKM20	Proud	Male	Timbavati-Klaserie PNR	2006-11-15 04:20:00	2006-11-15 05:01:00	2011-02-16 05:00:00
GSM	TKM21	Wessa	Male	Timbavati-Klaserie PNR	2006-11-15 06:00:00	2006-11-20 07:00:00	2011-06-17 04:00:00
Satellite	KEM01	Mbiri	Male	NP – north (south of Shing	2006-12-07 04:07:00	2006-12-07 21:14:00	2010-12-06 02:28:00
Satellite	KEM02	Tercievo	Male	NP – north (south of Shing	2006-12-07 05:25:00	2006-12-07 20:24:00	2010-04-22 06:08:00
Satellite	KEM03	Mune	Male	NP – north (south of Shing	2006-12-07 06:19:00	2006-12-07 21:50:00	2011-02-04 10:31:00
Satellite	KEM04	Quinto	Male	NP – north (south of Shing	2006-12-07 08:06:00	2006-12-07 19:11:00	2010-04-08 11:19:00
Satellite	KEM05	Tsevo	Male	NP – north (south of Shing	2006-12-07 08:45:00	2006-12-08 09:00:00	2009-05-03 12:25:00
Satellite	KEM06	Nkombo	Male	NP – north (south of Shing	2006-12-07 10:21:00	2006-12-07 17:03:00	2009-04-13 14:33:00
Satellite	KEM07	Nhungu	Male	NP – north (south of Shing	2006-12-07 10:32:00	2006-12-07 11:49:00	2010-03-14 12:17:00
Satellite	TKM05	Mac	Male	Timbavati-Klaserie PNR	2007-02-17 10:00:00	007-02-17 23:58:00 P	2010-08-13 07:08:00
GSM	TKM22	Mellow	Male	Timbavati-Klaserie PNR	2007-04-13 07:00:00	2007-04-13 07:03:00	2011-07-30 00:00:00
GSM	TKM23	Captain Hook	Male	Timbavati-Klaserie PNR	2007-04-13 05:35:00	2007-04-13 06:01:00	2011-06-15 08:00:00
GSM	TKM24	Snap	Male	Timbavati-Klaserie PNR	2007-06-06 05:45:00	2007-06-06 06:01:00	2008-01-21 22:00:00
GSM	TKM25	Iain	Male	Timbavati-Klaserie PNR	2007-06-06 06:50:00	2007-06-06 07:00:00	2008-06-14 12:00:00
GSM	TKM26	Namaste	Male	Timbavati-Klaserie PNR	2007-06-06 08:20:00	2007-06-06 09:00:00	2010-10-15 08:01:00
GSM	TKF09	Yvonne	Female	Timbavati-Klaserie PNR	2007-07-21 06:04:00	2007-07-21 06:54:00	2008-07-02 14:00:00
GSM	TKF01	Diney	Female	Timbavati-Klaserie PNR	2007-11-17 03:50:00	2007-11-17 12:01:00	still deployed
GSM	TKM27	Vee	Male	Timbavati-Klaserie PNR	2007-11-17 05:25:00	2007-11-17 12:00:00	2008-07-02 06:00:00
GSM	TKM12	Intwandamela	Male	Timbavati-Klaserie PNR	2008-04-26 05:15:00	2008-04-26 06:03:00	still deployed
GSM	TKM07	Al	Male	Timbavati-Klaserie PNR	2008-05-27 13:06:00	2008-05-27 14:00:00	still deployed
GSM	TKF09	Yvonne	Female	Timbavati-Klaserie PNR	2008-07-02 14:15:00	2008-07-02 15:00:00	2011-02-02 11:00:00
GSM	TKF04	Umbabat	Female	Timbavati-Klaserie PNR	2008-07-03 06:37:00	2008-07-03 07:00:39	still deployed
GSM	TKF07	Summer	Female	Timbavati-Klaserie PNR	2008-07-03 08:23:00	2008-07-03 09:00:00	still deployed
GSM	TKM13	Matambu	Male	Timbavati-Klaserie PNR	2008-07-24 09:00:00	2008-07-24 09:02:00	still deployed
GSM	TKM28	Irving	Male	Timbavati-Klaserie PNR	2010-02-02 06:00:00	2010-02-02 06:00:00	still deployed
Satellite	KNF04	Agnes	Female	ruger NP – far north (Pafu	2009-10-10 06:40:00	2009-10-11 06:17:06	2012-10-07 06:12:00
Satellite	KNF05	Colleen	Female	ruger NP – far north (Pafu	2009-10-10 08:00:00	2009-10-10 20:54:00	2012-06-19 00:03:00
Satellite	KNF06	Zingi	Female	ruger NP – far north (Pafu	2009-10-10 09:30:00	2009-10-10 20:56:00	2012-10-07 04:22:00
Satellite	KNM01	Mapimbi	Male	ruger NP – far north (Pafu	2008-10-30 05:00:00	2008-10-30 05:00:00	2011-11-19 06:43:00
GSM	TKF03	Mandy	Female	Timbavati-Klaserie PNR	2009-01-24 04:15:00	2009-01-24 05:00:43	2010-04-02 01:00:43
GSM	TKM10	Soshangane	Male	Timbavati-Klaserie PNR	2009-01-24 06:30:00	2009-01-24 07:01:00	2009-07-30 09:01:00
Satellite	KNM05	Mondli	Male	ruger NP – far north (Pafu	2009-10-10 04:45:00	2009-10-10 20:50:00	2011-01-19 15:09:00
Satellite	KNM06	Jabulani	Male	ruger NP – far north (Pafu	2009-10-10 05:50:00	2009-10-10 06:01:00	2011-11-14 05:58:00
Satellite	KNF01	Sarita	Female	ruger NP – far north (Pafu	2009-07-18 06:25:00	2009-07-18 08:58:00	2010-09-11 22:42:00
Satellite	KNM02	Gila	Male	ruger NP – far north (Pafu	2009-07-18 07:50:00	2009-07-18 08:30:38	2011-11-07 10:37:00
Satellite	KNM03	Nwambi	Male	ruger NP – far north (Pafu	2009-07-18 09:17:00	2009-07-19 07:29:00	2012-06-18 00:06:00
Satellite	KNM04	Bvekenya	Male	ruger NP – far north (Pafu	2009-07-18 10:18:00	2009-07-19 07:18:00	2012-04-26 00:49:00
Satellite	KNF02	Nwamkwimbi	Female	ruger NP – far north (Pafu	2009-07-18 11:26:00	2009-07-19 08:53:00	2012-10-07 03:50:00
Satellite	KNF03	Mangala	Female	ruger NP – far north (Pafu	2009-07-18 14:10:00	2009-07-19 05:47:00	2012-05-12 05:20:00
Satellite	TKM05	Mac	Male	Kruger NP - Phalaborwa	2010-08-13 07:52:00	2010-08-13 20:49:00	still deployed
Satellite	TKM06	Classic	Male	Timbavati-Klaserie PNR	2011-02-16 05:41:00	2011-02-16 07:00:00	still deployed
GSM	TKM20	Proud	Male	Timbavati-Klaserie PNR	2011-02-16 05:25:00	2011-02-16 06:01:01	still deployed
Satellite	TKF08	Lapajuma	Female	Timbavati-Klaserie PNR	2011-02-16 07:40:00	2011-02-16 07:58:00	still deployed
Satellite	TKM16	Tussle	Male	Timbavati-Klaserie PNR	2011-02-03 11:40:00	2011-02-03 17:03:00	still deployed
Satellite	TKM19	Gower	Male	Timbavati-Klaserie PNR	2011-02-03 07:45:00	2011-02-03 11:05:00	still deployed
GSM	TKF09	Yvonne	Female	Timbavati-Klaserie PNR	2011-02-03 05:47:00	2011-02-03 06:01:02	still deployed
Satellite	TKM21	Wessa	Male	Timbavati-Klaserie PNR	2011-06-17 12:08:00	2011-06-17 20:15:54	still deployed
Satellite	TKM09	General	Male	Timbavati-Klaserie PNR	2011-07-05 06:55:00	2011-07-07 01:09:39	still deployed
Satellite	TKM10	Soshangane	Male	Timbavati-Klaserie PNR	2011-08-30 12:50:00	2011-09-05 07:50:46	still deployed
Satellite	BKF01	Charlize	Female	Balule-Klaserie PNR	2012-04-23 13:20:00	2012-04-23 16:41:00	still deployed
Satellite	KNM05	Mondli	Male	ruger NP – far north (Pafu	2012-05-12 07:29:00	2012-05-29 10:36:00	still deployed
Satellite	KNF03	Mangala	Female	ruger NP – far north (Pafu	2012-05-12 08:34:00	2012-05-29 13:43:00	still deployed
Satellite	KCM01	Mighty Craic	Male	Kruger NP - Phalaborwa	2012-06-15 09:07:00	2012-06-15 12:15:00	still deployed
Satellite	KNM01	Mapimbi	Male	ruger NP – far north (Pafu	2012-06-19 06:30:00	2012-06-19 10:12:00	still deployed
Satellite	KNF05	Colleen	Female	ruger NP – far north (Pafu	2012-06-19 08:15:00	2012-06-19 12:56:00	still deployed
Satellite	KNF01	Sarita	Female	ruger NP – far north (Pafu	2012-06-18 14:50:00	2012-06-18 16:24:00	still deployed
Satellite	KNM03	Nwambi	Male	ruger NP – far north (Pafu	2012-06-18 13:37:00	2012-06-18 16:34:00	still deployed
Satellite	KNF02	Nwamkwimbi	Female	ruger NP – far north (Pafu	2012-10-07 04:30:00	2012-10-07 11:40:00	still deployed
Satellite	KNF06	Zingi	Female	ruger NP – far north (Pafu	2012-10-07 05:30:00	2012-10-07 09:31:00	still deployed
Satellite	KNF04	Agnes	Female	ruger NP – far north (Pafu	2012-10-07 07:00:00	2012-10-07 10:58:00	still deployed

The precision of the GSM-GPS collars (Hawk 105 collars, African Wildlife Tracking, South Africa, Pretoria) were tested both within the APNR and the KNP (De Knegt et al. 2011) and found to be <27.8m for 95% of the records. Field testing of the satellite tracking devices (model AWT SM2000E, African Wildlife Tracking, South Africa, Pretoria) had a root mean square error of <30 m with expected location success between 88-96% when tested in the field (Harris et al. 2003, Young 2010). The final elephant tracking data set was obtained via a "data downloader" supplying near real-time entry of data into a geodatabase while a data filter removed obviously erroneous GPS fixes, based on a maximum rate of travel (as used by Austin et al. 2003). Data gaps due to field conditions such as thick vegetation, topography, satellite positioning or improper collar angles were also filtered until a cleaned dataset was imported into a number of formats. Detailed analyses were conducted as part of scientific publications and M.Sc. theses currently under review. Hence only the main findings will be highlighted here while ArcGIS 10.1. was used to construct point/time density maps for bulls and cows of the APNR and Kruger East separately. Analyses methods for the Kruger North study were discussed in detail the final report for Grant (96200-9-G251).

<u>Large tree monitoring project</u>

Wire netting of trees

Trees, defined as single stemmed woody plants, more than 2 m tall were considered suitable for treatment with wire netting. At some study sites all trees within a defined area were wire netted while at others wire netting was placed on some trees while leaving others as controls. At the Vlakgezicht, Ntsiri and Rock Fig study sites bird wire (13mm mesh, 1.8m tall) was wrapped around the tree trunk about 50cm off the ground to a height of approximately 230cm. On average 1.25m of wire was used per tree. The ends of the netting were stapled on the tree trunk with 25mm wire fencing staples. At the Sumatra study site part of the wire netting was folded double before stapling the two ends together to make allowance for the natural expansion of the tree over time. When placing wire netting around a tree, care was taken to cut a few loops of wire around the entrances of any holes left by squirrels or smaller nesting birds to ensure easy and safe passage for these inhabitants in and out of the tree trunks. At the Charloscar study site diamond mesh with a 50 mm diameter was nailed onto the trees using 3 inch nails. At the De Luca study site bird wire with a 50 mm diameter was stapled onto the trees often at a height more than 50 cm off the ground.

Study sites of large trees monitored throughout the APNR

Six study sites have been established within the APNR (Figure 2). On the Vlakgezicht property in the Timbavati a selection of 64 trees were initially monitored in July 2004. In November-December 2004 this study site was extended to include an additional 51 trees. In October 2005 a further 129 trees were incorporated into the monitoring programme. In February 2007 a total of 850 trees were labelled which were again monitored in 2008 and 2012. On Ntsiri in the Umbabat 100 trees have been monitored since 2005 with 10 additional trees added in February 2007 and subsequent surveys repeated in 2008 and 2012. At the De Luca study site in the Umbabat, certain trees were netted in November 2006 while stones were packed at the base of others more than six years ago. Monitoring of the trees at the De Luca study site took place in March 2007 and surveys were repeated in 2008 and 2012. In the Klaserie at the Charloscar study site 315 trees were monitored in February 2007 after they had all been wire netted in April 2006. In May 2008 an additional 300 trees (unprotected by wire netting) on the periphery of the block with wire-protected trees were added to the sample as control trees and all trees were again surveyed in

2012. At the Rock Fig study site in the Timbavati 38 trees were monitored in February 2007 after they had all been wire netted in November 2006, with subsequent monitoring in 2008 and 2012. The Sumatra study site was first surveyed in 2008 with 1346 trees surveyed in 2012. Over time a limited number of new study trees have been added at some of the study sites whilst in the search for particular trees that could not be found or were presumed dead due to various factors.

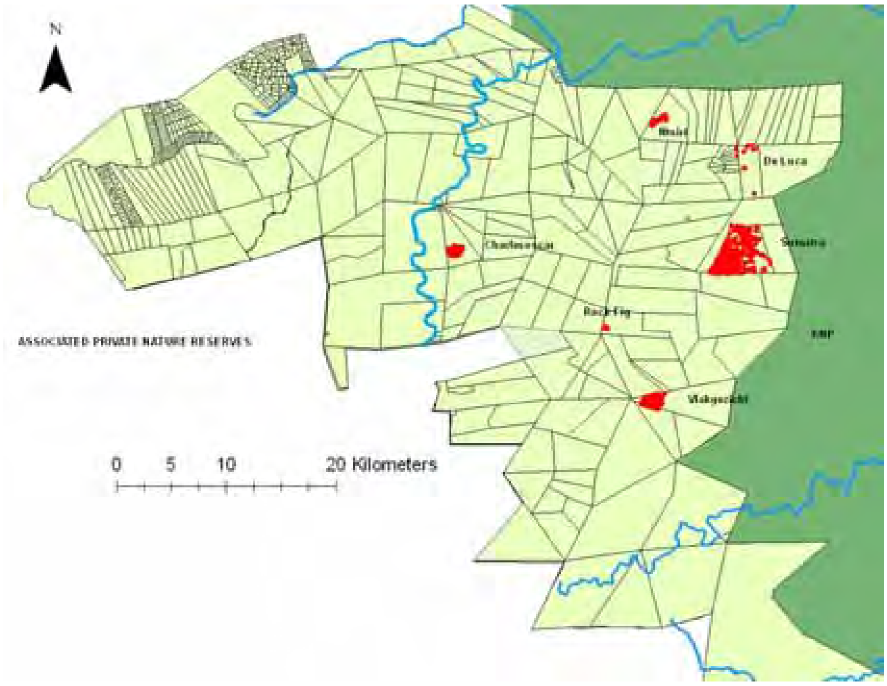


Figure 2 Location of the six study sites within the Associated Private Nature Reserves on the border with the Kruger National Park.

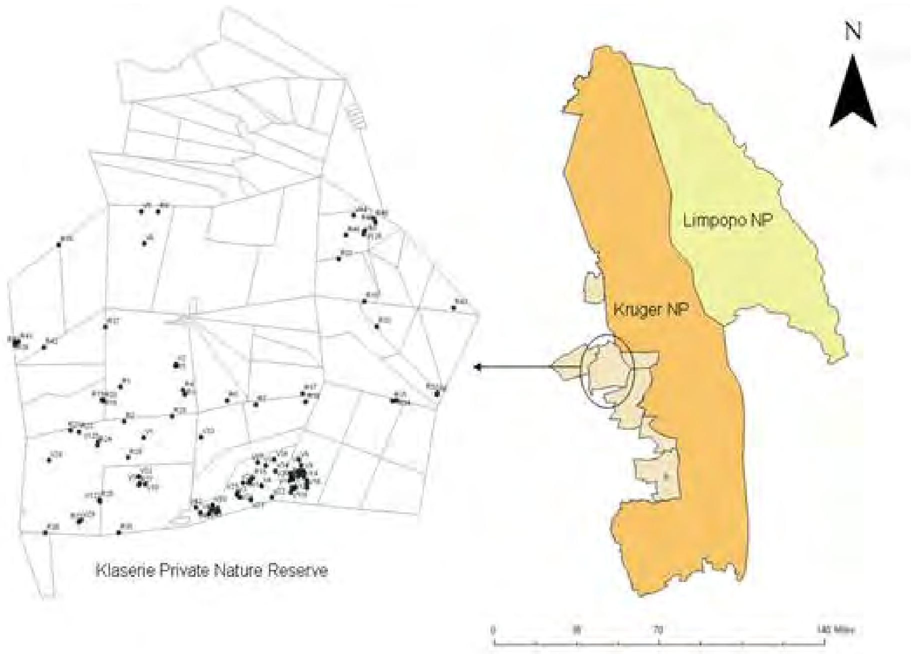


Figure 3 Location of large trees monitored for tree nesting vultures and raptors in the Klaserie Private Nature Reserve (KPNR).

In the Klaserie Private Nature Reserve (KPNR) 100 large trees with either raptor or vulture nests have been monitored since 2008 (95 *Acacia nigrescens* and five *Combretum imberbe,* Leadwood trees). Trees with nests were initially located by means of previously recorded GPS coordinates that were obtained during census operations (Figure 3). In 2011 the stem circumference and height of all *Acacia nigresens*, *Combretum imberbe* (Leadwood), *Sclerocarya birrea*, *Spirostachys africana* (Tambotie) and *Philenoptera violacea* (Apple-leaf) tree species, known to be used by vultures and raptors as nesting sites within the KPNR, were measured in a 20 m radius around the main stem of the centrally located large tree with a nest. The stem diameters of these trees were measured at 50cm from the ground as standard DBH measurements were not possible for younger age classes. Measurement of trees in a 20 m radius of trees with nests provided an indication of the potential regeneration of the surrounding vegetation and the future replacement of trees with nests. In 2012 an additional 200 *Acacia nigrescens* control trees without nests but in close proximity to the trees with nests were monitored as control trees.

1. Each large tree is given a code by hammering a numbered washer at breast height into the tree. Where two trees are less than one metre apart, one label is used for both trees but data from each tree is distinguished when recorded on the datasheet.
2. For trees with large tree nesting bird nests, a photograph of each tree was taken together with an observer of known height to enable finer scaled morphometric measurements at a later stage. This procedure will now be extended to incorporate all monitored trees.
3. The tree species is recorded with the focus being on monitoring Marula (*Sclerocarya birrea*) and Knobthorn (*Acacia nigrescens*) trees although False Marula (*Lannea schweinfurthii*) trees are also monitored when found. If the tree is a Marula tree the sex is determined by looking for fruit kernels on the ground as elephants have been reported to injure female more heavily than male trees (Hemsborg & Bond 2006).
4. The tree location is recorded by writing down the GPS co-ordinates (decimals degrees h dd. ddd) while standing as close to the tree as possible after waiting for the GPS reading to record location with an accuracy of at least a 5m radius.
5. Stem diameter is recorded at breast height in cm
6. The height of the tree canopy is estimated at <1m, 1-2m, 2-3m, 3-5m or >5m while in the field
7. The impact type is coded as:
   BS-bark stripping
   BBA-Primary branch breaking to access smaller plant parts
   MS-Main stem breakage as the main stem has been snapped off
   UR-Uprooting, where the main stem had been pushed over
8. The extent of the impact for each of the different impact types is recorded according to the following classes:
   Class 1: none
   Class 2: < 1%
   Class 3: 1-5%
   Class 4: 5-10%
   Class 5: 10-25%
   Class 6: 25-50%
   Class 7: 50-75%
   Class 8: 75-90%
   Class 9: 90-99%
   Class 10: 100%
   - Bark stripping (BS) is estimated according to the above mentioned impact classes by looking at the proportion of the circumference stripped of bark and not the length of bark that has been stripped. A tree that has been totally ring-barked fell will fall within impact class 10 for example.

- Primary branch breaking to access smaller plant parts (BBA) is estimated according to the proportion of primary branches that has been broken. If for example a tree only has two primary branches and one of these has been broken then the impact category for BBA will be class 6 or 7, depending on whether the broken branch is the smaller or larger of the two branches. The suitability of the hollow left behind as a potential bird nesting site after primary branch breakage, should be recorded.
- If the tree is uprooted (UR) or the main stem broken (MS) within the past season and the tree is still alive then the impact category is placed into class 9 (90-99%). If the woody plant has subsequently died then the impact is scored at 100% (class 10). If the tree is uprooted or the main stem snapped long enough ago for the re-coppicing material to form the main feature of the tree, then the impact class is scored according to the amount of re-coppice material present. If, for example, the main stem was snapped but the re-coppiced material now makes up 2/3 of the tree, the impact would be MS class 7 with a note made that the tree has recoppiced.

9. The persistence of a tree to the next annual monitoring period is gauged and recorded according to the following criteria:
    - ‘BS die-back’ is recorded in the persistence column for all bark-stripping (BS) events that fall into Class 8 or more and where die-back on the branch tips is visible.
    - ‘BS alive’ is recorded in the persistence column for all bark-stripping (BS) events that fall into Class 8 or more but where no die-back is recorded on the branch tips. For Marula trees this often occurs due to healing of the debarked area.
    - Unless otherwise specified in the field, ‘hedged’ is recorded in the persistence column where primary branch breaking to access smaller plant parts (BBA) events fall into Class 8 or more and where the tree’s height had been altered from above 5m to below 5m. The sex of all Marulas that are hedged, are recorded as ‘unknown’ as these trees don’t appear to bear fruit or alternatively fruit kernels beneath these trees are either very old or rare. Hence they could have incidentally been carried there by elephants or by baboons.
    - ‘Pollard’ (O’Connor *et al.* 2007) is recorded in the persistence column where the main stem has been snapped and the tree has either re-coppiced or the bark is still found to be alive. The sex of all Marulas that have been pollarded more than one year ago are recorded as ‘unknown’ for the same reasons as outlined above.
    - ‘UR-r’ is recorded in the persistence column for all uprooted trees that have re-coppiced or whose branches are still alive. The sex of all Marulas that have been uprooted more than one year ago is recorded as ‘unknown’ for the same reasons as outlined above.
    - ‘Dead’ is recorded in the persistence column for all trees that have died due to extensive bark-stripping or snapping of the main stem by elephants in the past. ‘Dead-natural’ is recorded for all trees that have presumably died due to insect attack, wind toppling or fire and which had no or very little other signs of elephant impact (Class 3 and lower) during pervious surveys. ‘Dying-natural’ was recorded for all trees that had signs of die-back on the branches due to insect attack, wind toppling or fire and which had no or very little other signs of elephant impact (Class 3 and lower) during pervious surveys.
10. For trees with large tree nesting bird nests, measurements of the diameter of bark that has been removed is made. Three visible lines should be cut on the cambium, one at the broadest section that has been removed and on below and above this middle line closest to where the bark might start rejoining to aid measurement the

following year. This procedure will now be extended to incorporate all monitored trees.

11. Tusk entry height: These measurements are only applicable where bark stripping has occurred and scars are visible where the tusk entered the tree. The height above the ground of the tusk entry point is measured. These measurements are only taken if the scar represented a tusk entry point otherwise it was preferably omitted.
12. Age of impact: ‘Recent’ or current season impact is distinguished from old impact by the pinky fleshy colour of the exposed stem in the former
    - Recent (within the past month)
    - Within the past dry/wet season (6 month period)
    - Within the past year (past 12 months)
    - More than a year old (more than 12 months)
13. Treatment is recorded as ‘none’, ‘wire-netting’, ‘natural protection’ by other plants, and protection by ‘stone packing’ or presence of ‘bee hive’.
14. Additional notes that are made include any healing that has subsequently occurred (especially for old Marula bark-stripping events). The condition of the treatment method and whether it has deteriorated (wire rusted or too loose) is recorded. Notes are made on whether the wire has been penetrated by an elephant tusk (scaring on the bark beneath) or merely tested by an elephant (eye of the wire stretched but bark left untouched beneath).
15. The presence of Marula or False Marula seedlings (trees below one meter with a circumference of less then 5 cm) is recorded.
16. The presence of a bird nesting site (either Southern Ground Hornbills or raptors and if possible the species of raptor) is recorded. Notes are taken on whether the nesting site is active.

The frequency of occurrence of a specific impact type was determined across tree species for each site individually. The proportion that each of the impact types contributed to the total across all impact types within a specific size category (diameter at breast height) was determined irrespective of the species. Likewise, the proportion that each of the impact intensity classes contributed to the total across all impact classes within a specific size category (diameter at breast height) and for each impact type separately was determined irrespective of the species.

Species specific proportions of trees were grouped as either having no elephant impact, light to moderate bark-stripping (BS) and/or primary branch breaking to access smaller plant parts (BBA), or moderate to heavy BS. Trees that were either hedged, pollard or uprooted in the higher impact classes, were grouped as being ‘structurally changed/modified’ by elephants. Trees that were heavily impacted upon by elephants which eventually lead to their death, or which could not be found in subsequent years of surveying, were described as having died due to elephant effects. Trees with no elephant impact or that were impacted upon in the lower elephant intensity classes but died after having signs of insect attack, fire scaring or wind toppling, were grouped as having died due to other causes. Included in this category were trees that died due to unknown causes (possibly shifting water tables etc.) or which could not be found in a particular year but were not heavily impacted upon by elephants in previous years.
To predict what proportion of a particular species which was still alive at the last survey may be more susceptible to mortality in future years, species specific proportions of trees were determined by combining trees with no to little elephant impact (<50%), or moderate to heavy elephant impact (>50%) with the presence or absence of other external signs of agents which could compromise the survival rates of trees in future (insects, fungus, fire or

wind). Trees that had moderate to heavy elephant impact together with the presence of other external agents were considered to be the most vulnerable in future years.
Survival curves were used to test tree persistence and nest persistence of large tree nesting birds by means of the Mantel-Cox test. This nonparametric test was used for the analysis of survival curves on the basis of the hazard rate using censored data (Fry, 1992). The following survival curves were contrasted for each of the study sites separately: (1) tree persistence where only elephant induced tree mortalities were considered versus mortalities of trees irrespective of the underlying cause of death (2) tree persistence where trees were wire-net protected versus unprotected trees where only elephant induced mortalities were brought into consideration (3) tree persistence for trees with large tree nesting birds' nests versus nest persistence within these trees.

The proportion of *Sclerocarya birrea* trees of a particular sex which were subjected to the various types of impact of different intensities were determined by counting the frequency of a particular impact intensity for each impact type and for each of the sexes. Fisher's exact test was used to test for significant associations between impact and sex of the tree for each of the impact types after grouping impact intensity classes into either with or without impact to account for low frequencies.
Pie-charts were used to contrast wire-net protected and unprotected trees in terms of the relative contribution of each impact type across species, irrespective of the age of the impact where trees had died in previous years of surveying. Chi square tests were used to test for associations between impact type and tree protection method. Trees that were alive as well as trees that had died due to having undergone BBA, MS or UR were grouped as structurally modified prior to analysis to account for small sample sizes in some categories.

Binary logistic regression with backward selection of significant variables (tree height, DBH, impact category and termite , fungus or insect presence was used to determine the relationship between elephant impact and bird nesting sites as well as the abandonment of a tree previously used as a nesting site. The data of the 100 trees with nests and the 200 control trees were used for the analysis of tree selection while for the abandonment of trees previously used as nesting sites only the 100 trees with nests' data was used in the analyses.

Results

Due to a constraint in length and as the results involve the production of various theses (both Hons. and M.Sc.) as well as scientific publications which are currently under review, I here list an except of the most significant findings. More detailed results can be made available upon request. As previously discussed, the results are highlighted for each of the four types of datasets and their related objectives.

<u>The ID Study</u>

The results of the ID study for the northern Kruger Project (Makuleke Concession Area), have been discussed in detail in the Final Report submitted to USFWS for the Grant (96200-9-G251). The results of the ID study for the APNR project are presently being analysed to produce a comprehensive report which will be submitted to the Wardens of the APNR by September 2013. This report will focus on bulls as a priority, in order to provide estimates on the number of bulls in each of the following age categories:

- Immature <15 years
- Young 15-25
- Adult >25-35
- Prime >35-55
- Senescing >55

This will enable us to evaluate the consumptive use practices in the APNR by assessing the demographic profile of the population and their perception of risk (Objective 4). Furthermore, this information will enable us to understand the movements and social importance of the remaining big tusked bulls within GLTP (Objective 5). Elephant tusks grow at a constant rate in length throughout life with the tusks of bulls increasing on average, at 11cm per year while female tusks increase at 8.5 cm per year. In elephants the rate at which the tusks increase in weight accelerates as the pulp cavity fills and this does not occur until old age in bulls. Although tusks increase in weight at a rate of 2g a day (Spinage 1994), the almost exponential increase in male tusks weight with age is not reflected in this daily rate of tusk growth. Laws (1966) found that in bulls the rate of tusk growth increases progressively throughout life to at least 240 lbs (109 kg) at 60±5 years. Growth in tusks does however depend on genetics, the geology of the place that the elephant occupies as well as the frequency at which the tusks are used. If there was no wear and tear on a bull elephant's tusks he could acquire tusks as long as 550cm in his lifetime however, bull's tusks generally reach 250cm in length upon old age (Spinage 1994). Hence, we plan to determine how many large tusked bulls are found within which age categories as big tusked elephants are more inclined to be older animals which are scarcer within a population. These findings will be provided independently or reported as part of the mid-term report if the renewal of this Grant (96200-9-G129), which was submitted at the end of November 2012, proves to be successful.

Questionnaire Surveys

I here focus on questionnaire surveys in relation to vegetation impact by elephants. A detailed report is available on the outcomes of human perceptions in relation to elephants, large trees and aspects of elephant management. This formed part of a B.SC. (Hons) by Adam Edge from Western Kentucky University.

Plant species of concern in relation to elephant impact

The abovementioned questionnaire survey distributed in 2003 identified three plant species of particular concern with regards to elephant impact. Consequently, the vegetation surveys focussed on elephant impacts on *Sclerocarya birrea*, *Acacia nigrescens* and *Lannea schweinfurtii* as these species are utilized in a similar way (bark-stripped for the two former species and large branch breakage or felling for all three species) and are often sought after by elephants in the presence of other species at particular times of the year (favoured species). Both *Sclerocarya birrea* and *Acacia nigrescens* were listed as two of five of the most important species in the KNP because collectively these species made up 80% of the total tree population (Van Wyk & Fairall 1969). In addition, *Sclerocarya birrea* has cultural, medicinal and economic uses (Roberts 1990, Palgrave 1993) while *Acacias* are often favoured by white backed vultures (*Gyps africanus*) as nesting sites (Murn *et al*.2002). Hence the vegetation study will continue using these species as key indicators of environmental change. Across all affected parties within the APNR, concerns increased for some species while for others it declined over the ten year period (Figure 4). The interaction between species of concern and time proved to be significant with the greatest relative concern being for *Sclercarya birrea* and *Acacia nigrescens* (Chi square = 19.6, *df*=10, P=0.033). These subtle changes over time where primarily driven by managers' opinions as there has been a decline in concern for other species (including *Grewia* spp.) together with a concurrent increase in concern for *Sclerocarya birrea, Acacia nigrescens* and *Lannea schweinfurtii.*

Bush encroachment and tall tree loss (STE-SA survey)

When considering how opinions of landowners, shareblock holders and managers have changed over time with regards to whether bush encroachment is taking place in the APNR, there was only an interaction between type of affected party and their opinion in 2003 (Chi square = 14.7, *df*=4, *P*=0.005). A large proportion of landowners disagreed that bush encroachment was taking place while most shareblock owners remained neutral on the topic. There is a general trend towards more affected parties agreeing that the bush has thickened with less parties being neutral on the topic as time has progresses (Figure 5).

Figure 4 The relative importance of various plants species identified as of concern to landowners, shareblock owners and managers within the APNR.

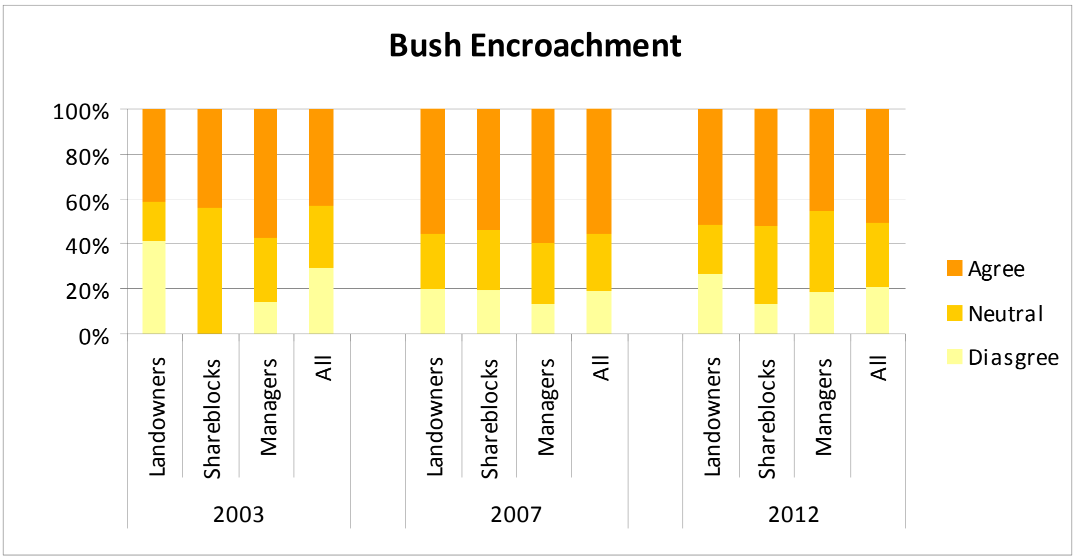


Figure 5 Perceptions of affected parties within the APNR over time and with regards to whether the bush has undergone encroachment.

When considering how opinions of landowners, shareblock holders and managers have changed over time with regards to tall trees that have been lost to the system, there was only an interaction between type of affected party and their opinion in 2003 (Chi square = 9.95, *df*=4, *P* =0.041). A large proportion of landowners agreed that bush encroachment was taking place while most shareblock owners remained neutral on the topic. There is a general trend towards more landowners agreeing that tall trees have been lost to the system while shareblock owners have become less neutral about the topic. Across all years, there have been a larger proportion of shareblock owners and managers who have been neutral about tall tree loss when compared to land owners. (Figure 6). In contrast to opinions regarding bush encroachment, the same landowners that completed the questionnaire over the 10 year period, have become less neutral on the topic of tall tree loss in latter years although the interaction effects between opinion and time was not significant (Figure 7).

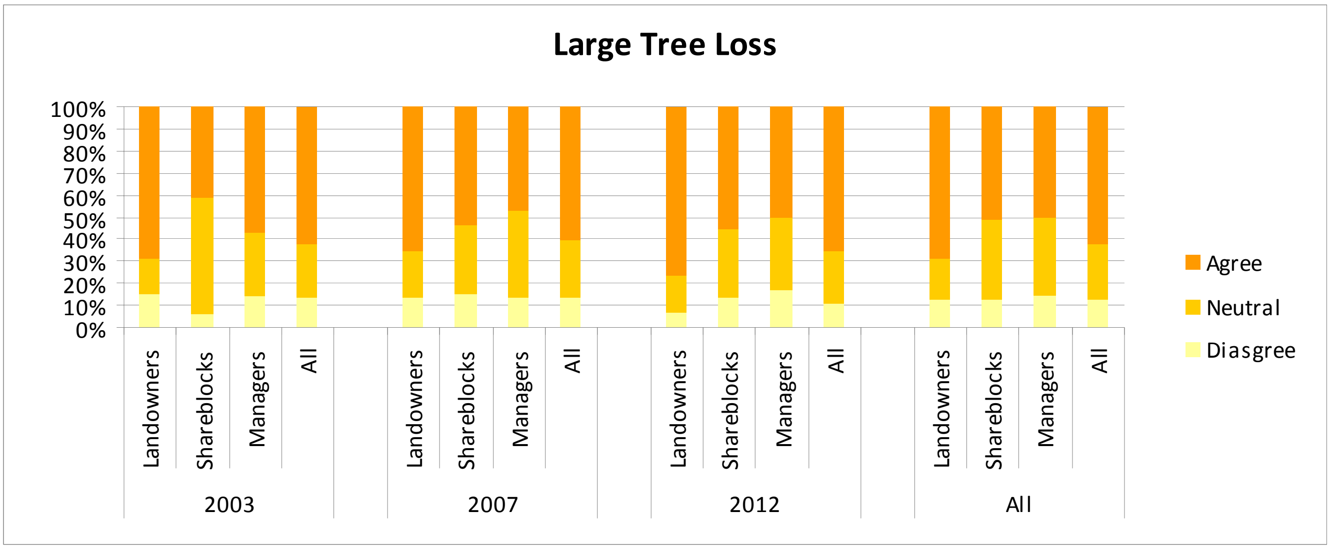


Figure 6 Perceptions of affected parties within the APNR over time and with regards to whether the tall trees have been loss from the system.

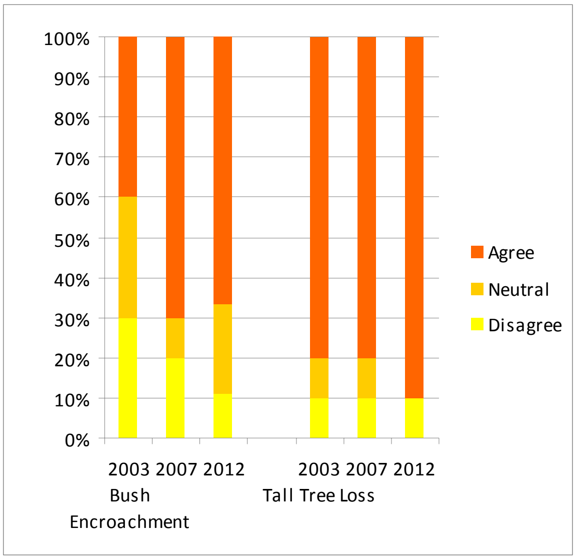


Figure 7 Perceptions of the same 10 respondents that answered the questionnaire three times over a 10 year period with regards to whether bush encroachment has taken place and whether tall trees have been loss from the system.

Perceptions on photos of various landscape types (WKU survey)

There was a significant association between landscape type and the different opinions of the respondents, whether residents or tourists (Chi square = 138.4, *df*=4, *P*<0.0001). Respondents were more frequently positive in attitude towards a photograph depicting a savannah landscape with tall trees and long grass, when comparing their response to scrubveld with no tall trees or a *Colophospermum mopane* dominated landscapes (Figure 8). Both residents and tourists evaluated scrub lands and savannas similarly and although tourists appeared to be more negative towards landscapes depicting savannas with tall trees than residents, the interactions between opinions of residents versus tourists and landscape type were not significantly different for these two landscape types. However, residents were more negative towards landscapes dominated by *Colophospermum mopane* (Chi square = 31.9, *df*=2, *P*<0.0001) than tourists (Figure 9). These results indicate that residents and tourists do have different aesthetic perceptions of what the landscape should look like and which vegetation types and structures are favoured.

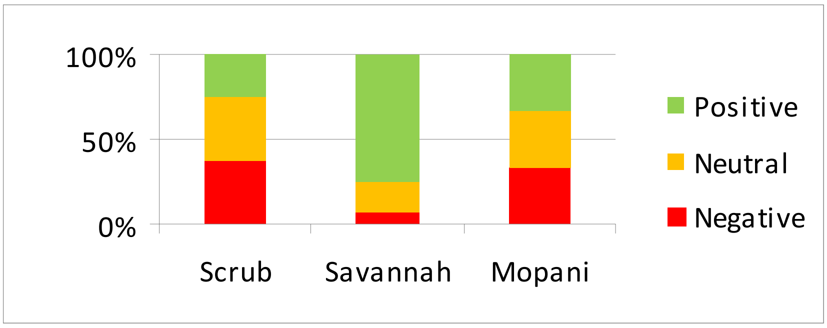


Figure 8 Perceptions of respondents towards photographs depicting a scrubland with no tall trees (scrub), a photograph of tall trees with waving grass (savannah) and a photograph of dense *Colophospermum mopane* veld (mopane). Respondents were asked to score the photos from 1-5 with '5' representing the most favourable score. Scores below '3' were taken as negative, '3' as neutral and larger than '3'as positive.

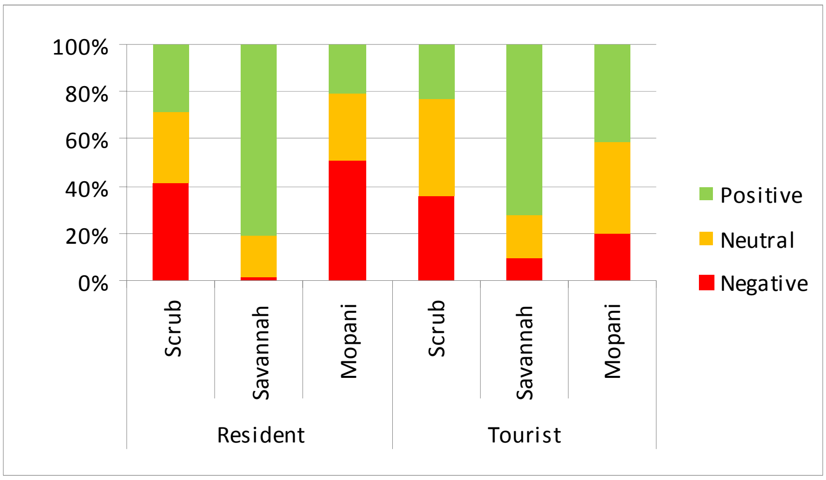


Figure 9 Perceptions on how residents versus tourists responded to photographs depicting a scrubland with no tall trees (scrub), a photograph of tall trees with waving grass (savannah) and a photograph of dense *Colophospermum mopane* veld (mopane). Respondents were asked to score the photos from 1-5 with '5' representing the most favourable score. Scores below '3' were taken as negative, '3' as neutral and larger than '3'as positive.

Perceptions of large trees that have or have not undergone structural modification (WKU survey)

There was a significant association between large tree impact and the different opinions of the respondents, whether residents or tourists (Chi square = 154.0, *df*=4, *P*<0.0001). Respondents were positively orientated towards an undamaged tree where as bark-stripped trees were less favoured and pollard trees were the least favoured (Figure 10). When considering the difference in opinion between residents as opposed to tourists, trends were similar but with residents feeling more strongly opposed to trees that had been impacted upon by elephants than tourists. Tourists were more inclined to not to be strongly opinionated and were consequently more frequently neutrally orientated towards the same set of questions as residents. There was a significant interaction between respondent type (resident versus tourist) and opinion with regards to trees with no impact, trees that were bark-stripped and trees that were pollard (Chi square = 16.6, *df*=2, *P*<0.0002, Chi square = 7.65, *df*=2, *P*<0.022 and Chi square = 7.85, *df*=2, *P*<0.020 respectively) as some tourists were opposed to undamaged trees while many were neutral in their opinion. Fewer tourists were opposed to bark-stripped and pollard trees but more were neutrally orientated when compared to residents. (Figure 11). These results indicate that residents and tourists do have different aesthetic perceptions on the visual consequences of elephant effects.

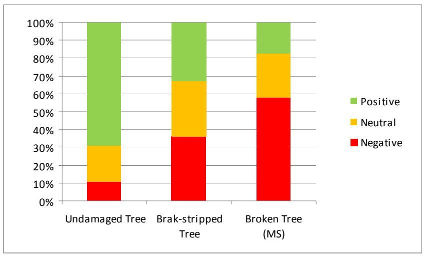


Figure 10 Perceptions of respondents towards photographs depicting a tall tree that has not been impacted upon by elephants (undamaged), a tree that has been bark-stripped and a tree that has been pollard (broken tree MS). Respondents were asked to score the photos from 1-5 with '5' representing the most favourable score. Scores below '3' were taken as negative, '3' as neutral and larger than '3'as positive.

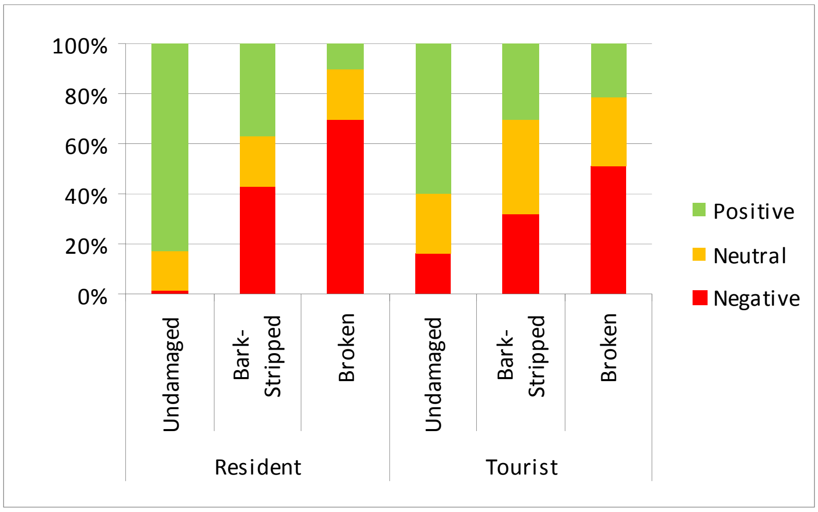


Figure 11 Perceptions on how residents versus tourists responded to photographs depicting a tall tree that has not been impacted upon by elephants (undamaged), a tree that has been bark-stripped and a tree that has been pollard (broken tree MS). Respondents were asked to score the photos from 1-5 with '5' representing the most favourable score. Scores below '3' were taken as negative, '3' as neutral and larger than '3'as positive.

<u>GPS telemetry study</u>

The results of the telemetry study for the northern Kruger Project (Makuleke Concession Area) have been discussed in detail in the Final Report submitted to USFWS for the Grant (96200-9-G251). I here focus on the Kruger East and APNR results followed by the abstracts from various theses and scientific articles which are currently under review and which tie into the objectives previously listed under this dataset in particular.

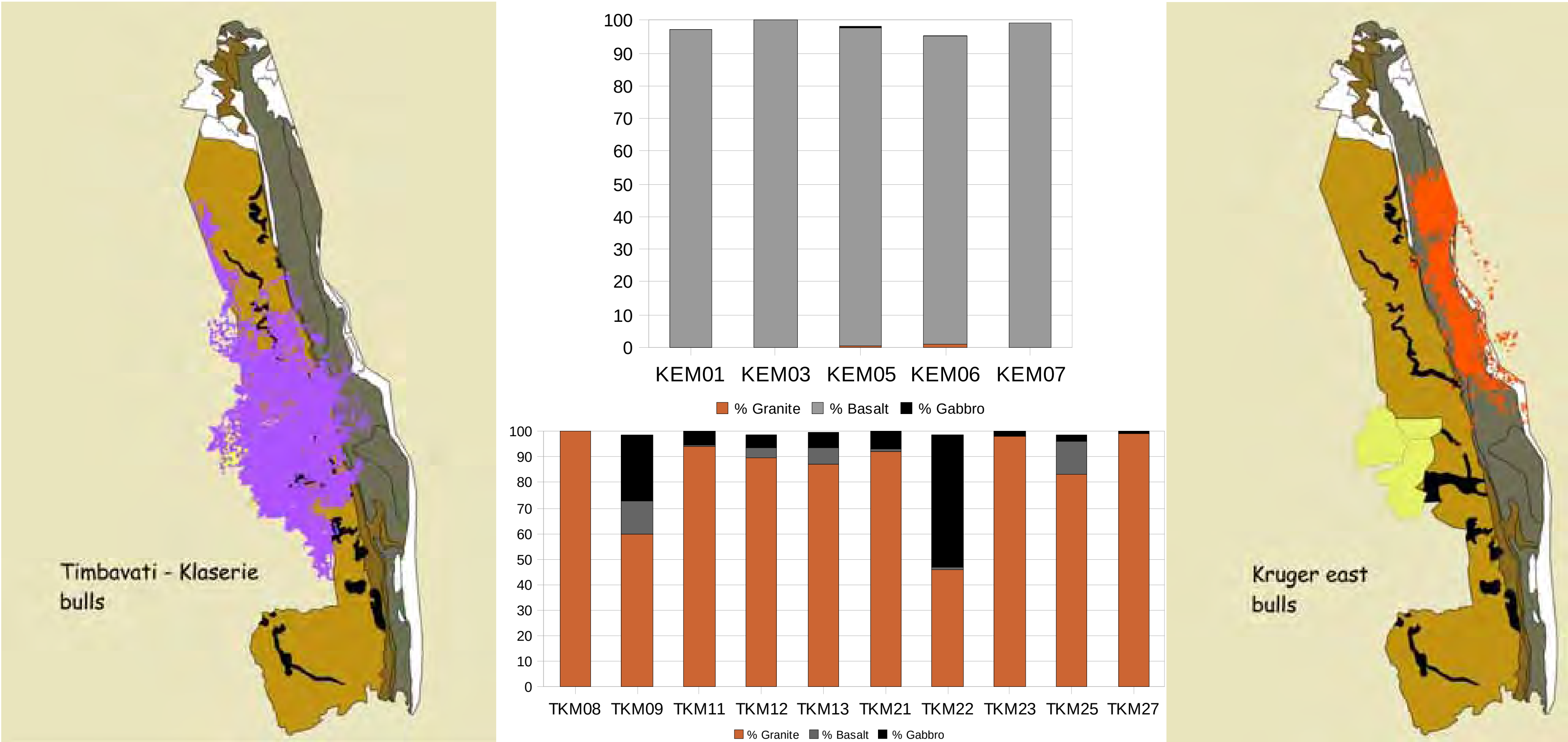
Kruger East Study site

Kruger National Park lies within the GLTP (refer to Figure 1). The removal of barriers to movement of wildlife between the clusters of Protected Areas that make up the GLTP will influence the efficacy of the SANParks management strategy. Similarly, the management strategy adopted by KNP may affect elephant populations in the other linked Protected Areas. Therefore, it is important to understand elephant distribution and range use patterns within the KNP and the possible driving forces behind such movements. The historic colonisation of KNP by elephants from Mozambique early in the 1900's (Whyte 2001) and the current reciprocal colonisation of Mozambique from KNP will contribute towards our understanding of the degree of linkage between elephant populations from different Protected Areas.

Part of the telemetry study run by STE-SA over the past decade involved the deployment of collars on seven adult bulls in the east and 12 collars in the north of KNP in 2006 and 2008-2012, respectively. In collaboration with SANParks, the objective was to identify movement routes across GLTP. An unforeseen insight gained from these collars and other collars deployed on elephants in the Private Nature Reserves to the west is an apparent separation of adult bull elephants along the granite-basalt geological divide. Initial results suggest that bulls collared on the eastern basalts of KNP do not move westward on the granite derived habitats, and similarly bulls collared in the west only make limited use of the basaltic areas (Figure 12). Hence this geological division within the adult bull population has important implications for the management of elephants as it establishes the largest spatial scale recognised by adult elephant bulls within this ecosystem, that being the largest scale at which they differentiate landscapes. This finding could influence the efficacy of management actions as it offers an opportunity to study the perception of landscapes by large herbivores and hierarchical patterns of habitat and resource selection when alternative options are available. It would potentially have implications for the process of genetic differentiation into demes (i.e. separate local random mating units). We therefore plan to make use of the DNA analysis of 73 different blood samples taken from animals whose home ranges are largely restricted to the granites and compare these with a near equal proportion of blood samples collected from animals that were darted by SANParks on the eastern basalts in order to determine the level of relatedness between the two spatially distinct populations. By so doing we hope to address the following key questions in the months to come:

1) Is there a genetic component to the pattern of landscape differentiation observed amongst adult bull elephants within the Greater KNP?
2) Is the pattern also applicable to other components of the population (females and younger bulls)?
3) If genetic differentiation within the KNP populations exists along geological formations, does it indicate recent colonisation from the east to the west (basalts to the granites)?

Time density analyses of elephants tracked in Kruger East have shown that certain landscapes are used more intensely than others. Preliminary results indicate that differential landscape use depends on landscape characteristics i.e. vegetation types possibly linked to geographical features as can clearly be seen that the more rugged granites to the west are largely been avoided by these study animals. Of the seven elephants that were collared, two moved and stayed in Limpopo National Park, four visited this Park and returned to KNP and one of the animals remained in KNP for the entire tracking period (Figure 13).



Mean (± SD) percentage occurrence of Timbavati-Klaserie and Kruger–east bull elephants on major geological formations in the Kruger NP.

	Granite	Gabbro	Basalt
Timbavati - Klaseie bulls (TKM)	84.91 (± 18.00)	10.56 (± 16.29)	3.95 (± 5.24)
Kruger - east bulls (KEM)	0.29 (± 0.34)	0.11 (± 0.13)	97.59 (± 2.21)

Figure 12. The distribution of elephant bulls collared in the west (Timbavati – Klaserie) and east of the KNP – Private Nature Reserve complex. Areas with an underlying granitic geology are beige and the basalt grey (Henley & Henley 2009).

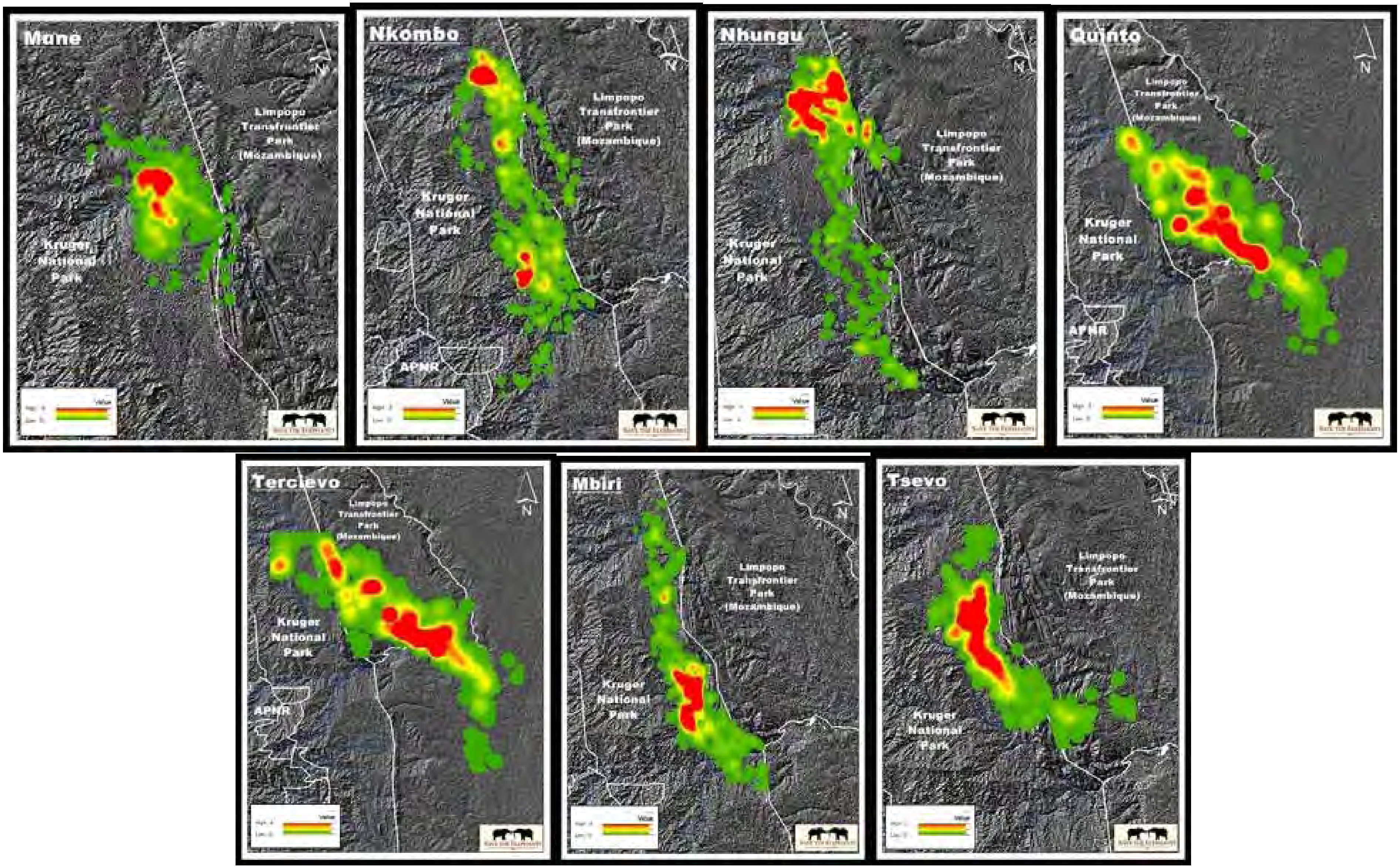


Figure 13: Time density analysis of large bulls tracked in the Eastern section of the KNP, bordering on Limpopo National Park in Mozambique.

The APNR study

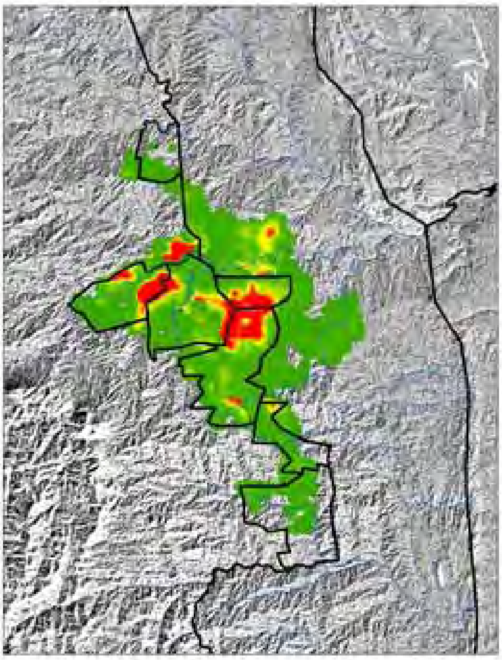
Various M.Sc. theses and scientific publications (listed under (e) project impact) will be addressing the objectives relating to this dataset and study area in the months to come. Where the aforementioned have been completed and are in review, the abstract is presented:

Do anthropogenic and natural features act as barriers to African elephant (Loxodonta africana) space use? (MSc by Kristy Robertson from the University of the Witwatersrand)
The degree that different landscape features influence elephants use of space in the Kruger National Park and surrounding private game reserves (Balule, Timbavati, Klaserie and Umbabat) is not known. The aim of my study was to assess landscape features which influence elephant space use at two different spatial scales: at a large scale representing home range selection within the landscape and a small scale representing core area selection within the total home range. I investigated the space use of 15 male and 6 female adult elephants over a three year period (June 2007-May 2010), using GPS data and satellite mapping analysis. The features selected for analysis as possible barriers to elephant space use were anthropogenic (fences, roads, railway lines and infrastructure) and natural features (rivers, geological features and vegetation). I also investigated the total and core home range size of elephants and whether elephant space use differed by sex and season. Males had larger total home ranges than females irrespective of season, but there were no size or seasonal differences of core home range size between the sexes. Elephants used features differently at the two spatial scales, differed in the use of features between seasons, and there was a difference between the sexes in the use of features. Fences, railways, rivers (in the wet season), geological features and vegetation types were the features that influenced elephant space use, and could be possible barriers at the large scale. Elephants occurred close to fences which possibly restricted their space use. Elephants also occurred close to railway lines but they might not have crossed the railway line. As expected elephants occurred less often at close distances to rivers in the wet season which could possibly be as a result of higher rainfall in this season, preventing elephants from crossing their usual riverbed corridors. Male and female elephants differed in the use of vegetation types found on particular geological features: males selected basalt and females selected granite areas for both the dry and wet seasons. Both male and female elephants were associated with a wider variety of vegetation types in the dry season, possibly because the limited food availability causes elephants to cover larger areas in search of food. Elephant space use was therefore governed by several features that may or may not restrict space use. My study, using satellite mapping analysis, can suggest what hinders movements of elephants and what is essential for assisting elephant space use, which could help conservation efforts for reserve design and corridor formation between reserves.

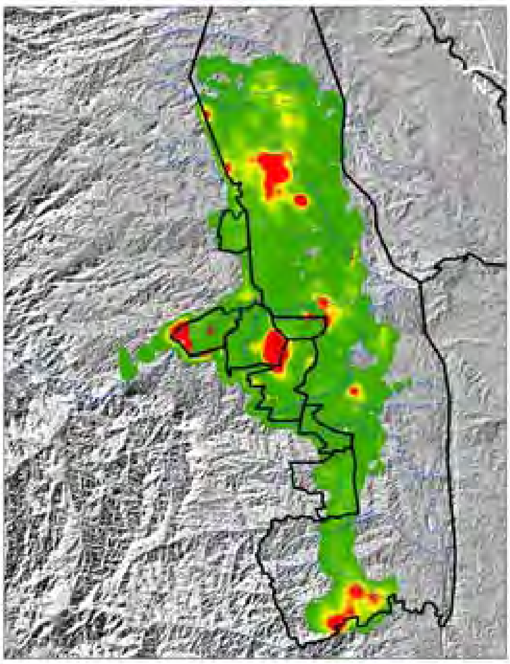
Musth Signatures from GPS Tracking Data – Do They Exist? *PlosOneB*
M.D. Henley; C.R. Addis; S.R. Henley; A. Ganswindt; S.B. Ganswindt; J. Wall and I. Douglas-Hamilton

Elephant bulls in musth exhibit a statistically distinguishable difference in movement pattern, exhibiting a more rapid rate of movement. The analysis of long-term movement datasets of long-lived species enables multi-phasic movement patterns (musth) to be identified. We argue that in prime bulls, musth is annually consistent and associated with a degree of site fidelity, enabling us to link movements to behavioral states. The importance and relevance of linking internal and external drivers of elephant movements to plausible ecological, social and demographic correlates is discussed within a unifying paradigm that has recently been proposed within the field of movement ecology.

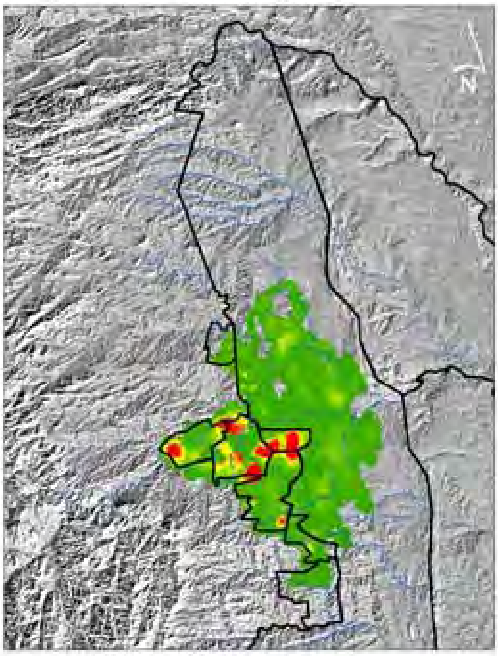
Overall, elephant's use of the APNR landscape appears to be dependent on their age and sex. Females show a higher degree of site fidelity compared to bulls. Young bulls (15-25 year old bulls that have not started coming into musth), appear to explore the landscape more widely. Adult bulls' (25-35 years old bulls which are starting to experience musth) intensity of landscape use appears to overlap with both those of females and prime bulls. Prime bulls (bulls older than 35 years of age with regular annual musth cycles) move relatively widely, especially when expanding their range during musth and away from their discreet non-musth areas (Figure 14).



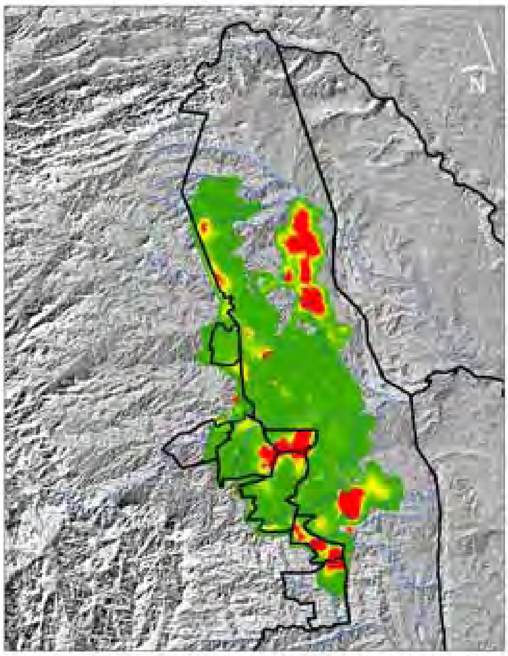
Females



Young bulls



Adult bulls



Prime bulls

Figure 14: Point density maps of all the females, the young-, adult- and prime bulls collared within the APNR.

Tree monitoring project

The results from the large tree survey can be summarised as follows:

- Impact intensity differed between sites with survival rates of trees (when considering elephant impact only) varying from as low as 55.3% to as high as 89.3 %.
- The Ntsiri and Valkgezicht study sites had the lowest survival rates over time but both these properties were also monitored for the longest period of time (seven and eight years respectively).
- Not only were a large portion of trees lost on the Ntsiri and Vlakgezicht properties due to elephant effects, but other causes of mortality also contributed significantly to the decline in survival rates over time. The survival curves for large trees based on elephant effects only, was significantly higher than the survival curves which accounted for all causes of mortality i.e. including death due to fire, insect attack, wind or other unknown causes.
- The Ntsiri and Vlakgezicht study site both had 10% of the large trees identified as vulnerable to future mortalities as these individuals had elephant impact in the moderate to high, impact categories concurrently with the presence of other external agents (fire scarring, insect attack, wind-toppling effects) which could compromise the survival of a tree. At the Ntsiri study site more *Sclerocarya birrea* were vulnerable than *Acacia nigrescens* while at the Vlakgezicht study site more *Lannea scweinfurthii* was vulnerable than *Sclerocarya birrea*.
- The study sites with the highest proportional mortality figures for large trees (Ntsiri and Vlakgezicht) have two factors in common which could explain the comparatively large loss of trees at these sites. Ntsiri experienced a management fire in 2006 while Vlakgezicht burnt in 2008. Both properties survival curves declined more steeply after these events. Furthermore, both these study areas have water points in amongst and in the immediate vicinity of the study sites which could be the cause of an elephants frequently encountering the large trees on their way to the water points.
- The survival rate of wire-net protected versus unprotected trees was significantly higher on the Sumatra and Valkgezight properties. Wire-net protection resulted in a survival rate difference between the wire-net protected and unprotected trees of 6.8% and 30.1% for Sumatra and Vlakgezicht respectively. Considering the vulnerability of some of the trees on Vlakgezight, the wire-netting of trees does offer important protection to large trees.
- Across all the study sites, wire-net protection generally lead to lower mortalities rates in trees and higher proportions of untouched trees, increased frequencies of primary branch breakage to access smaller plant parts concurrently with reduced proportions of trees that were either bark-stripped, uprooted or pollard.
- Properties were most wire-netting required maintenance (De Luca), experienced high proportions of testing /penetration of the wire-netting by elephants (up to 33% per year of survey). Hence maintenance of wire-nets is important to ensure the efficacy thereof over the long run.
- Study sites with no recent history of fire and where the large trees were monitored that were not in the immediate vicinity of a water point, generally experience comparatively low large tree mortalities (87.2 % survival rate for Charloscar).

Table 5 Summary of the survival statistics per study site as well the proportion and number of trees by type which have been identified as vulnerable to mortality in future. The average annual proportion of wire-net protected trees that were tested or penetrated by elephants is also provided.

Study Site	Survival Rate of Large Trees		Efficiency of Protection		Vulnerability of Trees	Average % Trees Tested/Penetrated per Survey Period
Charloscar	Elephant effects only	87.2%	With Wire	92.5%	Proportion 10%	5%
	All causes	84.8%	Unprotected	87.9%	Number and Type: 49 (18 Knobthorn, 24 Marula, 7 False Marula)	
	Difference significant?	No	Difference Significant?	No		
De Luca	Elephant effects only	n/a	With Wire	93.3%	Proportion 0%	33%
	All causes	n/a	Unprotected	100%	Number and Type: 0 (0 Knobthorn, 0 Marula, 0 False Marula)	
	Difference significant?	n/a	Difference Significant?	No		
Ntsiri	Elephant effects only	65.8%	With Wire	71.0%	Proportion 10%	3%
	All causes	52.3%	Unprotected	56.4%	Number and Type: 8 (3 Knobthorn, 5 Marula, 0 False Marula)	
	Difference significant?	Yes	Difference Significant?	No		
Rock Fig	Elephant effects only	89.3%	With Wire	n/a	Proportion 4%	5%
	All causes	78.9%	Unprotected	n/a	Number and Type: 1 (1 Knobthorn, 0 Marula, 0 False Marula)	
	Difference significant?	No	Difference Significant?	n/a		
Sumatra	Elephant effects only	86.4%	With Wire	89.0%	Proportion 20%	3%
	All causes	83.2%	Unprotected	82.1%	Number and Type: 152 (18 Knobthorn, 127 Marula, 7 False Marula)	
	Difference significant?	Yes	Difference Significant?	Yes		
Vlakgezicht	Elephant effects only	55.3%	With Wire	72.9%	Proportion 10%	8%
	All causes	40.3%	Unprotected	42.8%	Number and Type: 78 (17 nobthorn, 25 Marula, 35 False Marula)	
	Difference significant?	Yes	Difference Significant?	Yes		

Large trees with tree nesting birds

The results from the study with the vulture and raptor nesting sites in the KPNR can be bulleted as follows:

- Bark-stripping as an impact type was most prolific on large trees with nesting sites
- Elephant impact did not differ between trees with nests and control trees without nests but trees with nests were taller and a larger proportion of these trees had lower elephant impact and were less affected by insects and fungus
- Overall elephant impact was low, irrespective of tree or nesting bird type. Of the trees with nests there were significantly more trees in lower impact classes with few in higher impact classes (>50%)
- Impacted trees with vulture nests had relatively lower elephant impact compared to trees with raptor nests as 90% of trees with vulture nests had low elephant impact while only 71% of impacted trees with raptor nests had low elephant impact. Vultures may be more sensitive to the die-back of the nesting tree as they build their nests on the upper crown and require a fine network of branches to enable sufficient buoyancy to carry the nest. Raptors prefer to build nests in the fork of the upper branches.
- Higher elephant impact classes increased the chances of recording insects and fungus.
- A tree with larger DBH and an absence of insect activity had higher survival rates
- Elephants could indirectly be influencing survival rates of large trees as accumulated elephant impact on older trees could render these trees as unusable as potential nesting sites because of increased arthropod and fungus evasions over time.
- In 2008, at the start of the study, all monitored trees were still alive and had active nest sites. The survival rate of nests declined significantly more than trees (Log rank Mantel-Cox Test, Chi square = 131.2 *df*=1, *P*<0.0001).with as much as 79%of the nests being lost by 2012. Over the five year period, survival rates of trees had dropped to 78.5±3.58% (mean ± SEM) whilst the survival rate of nests was 21.3±3.04% (mean ± SEM) since the study was initiated (Figure 15).

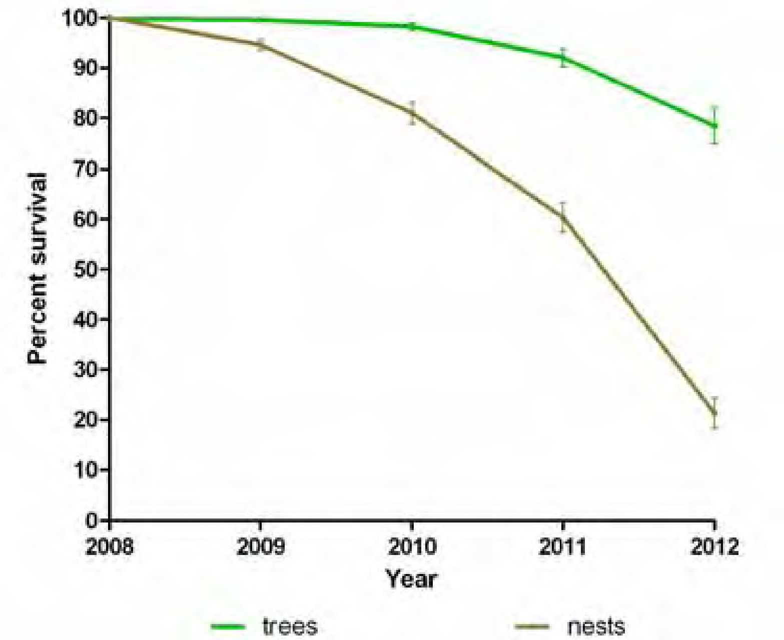


Figure 15 Survival curves for trees with vultures and raptors and for nest found within these large trees respectively.

- Overall, there is a high generation/recruitment of potential nesting sites on which elephants have a negligible influence as an inverse J-shape was found with most trees in younger age classes (Figure 16)

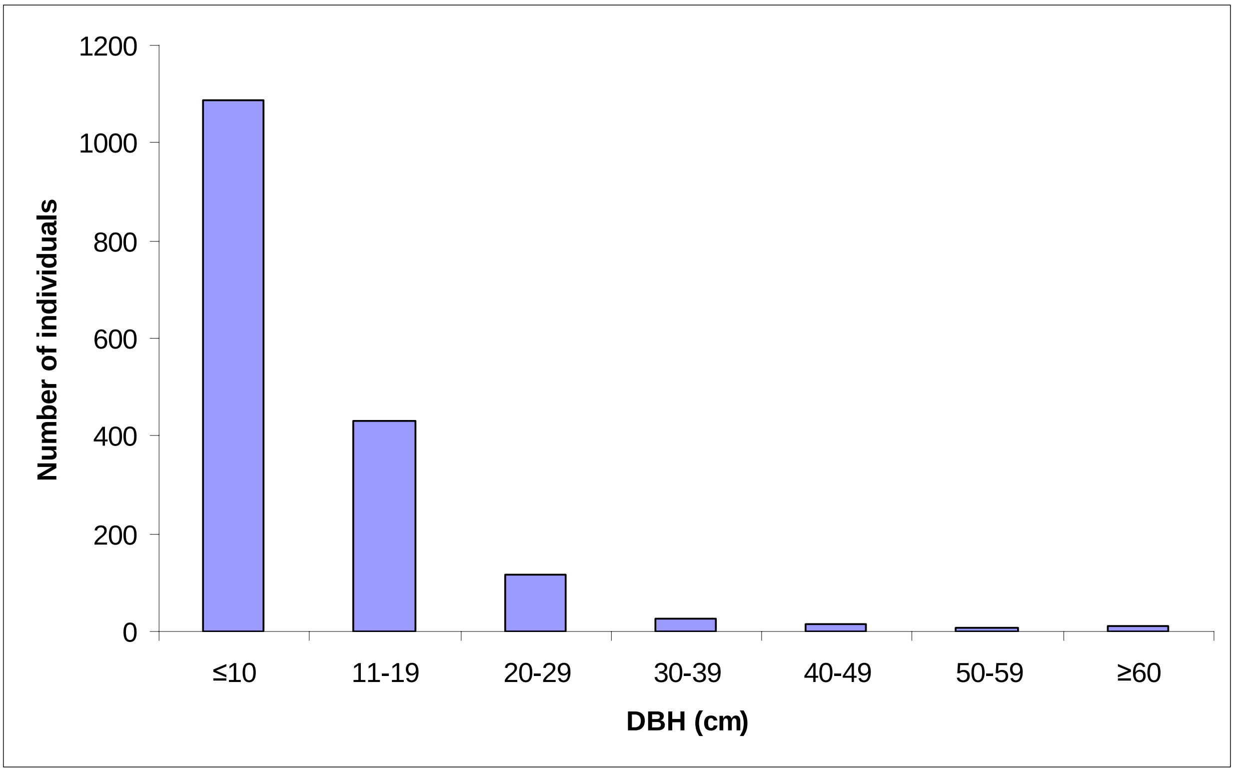


Figure 16 The frequency of seedlings and younger trees found in the immediate vicinity of the centrally located large trees with nesting sites

d) Project challenges

One of the largest challenges was to relocate from the Timbavati Private Nature Reserve in November 2012 to the Balule Private Nature Reserve in the far west of the APNR. The relocation process resulted in a loss of routine work for approximately a two month period. Most of the collared studied animals within the APNR remain towards the eastern sections of the Private Reserves, the small team on the ground and the distance between the newly founded research base and the majority of the collared study animals presents a challenge.

In January 2013, the Limpopo and Levhuvhu River came down in flood and largely destroyed the Wilderness Safari Camp along its banks. The Camp has now closed for operational reasons and as the roads in the area were also damaged, no game drive vehicles are undertaking routine game-drives at present. This means that ID photos of elephants in the region are no longer being collected on a daily basis. Although nine of the 12 collared study animals were recollared in 2012, most of the data in this area will now have to be collected remotely from the collared individuals until such time as the roads have been repaired and the camp rebuilt. A M.Sc. student has however been sourced from the University of the Witwaterand who will be able to make use of the opportunity to analyse the collected data in relation to environmental variables and satellite imagery.

Another challenge will be the recollaring of the large tusked elephants in keeping with Objective 5, whose collars will, over time, start running down. Re-collaring of these elephants will only possible as donor funding becomes available. As the study animals often moved into remote areas, it may not always be possible to access them before the collar batteries have run down.

e) Project's impact

The northern Kruger Project's (Makuleke Concession Area) impact has been discussed in detail in the Final Report submitted to USFWS for the Grant (96200-9-G251). I here focus more on the Kruger East and APNR project's results. The information that has been gathered on the movements of elephants within the APNR have been communicated to all interested parties via monthly Google Earth Tracking reports which will now be circulated as a seasonal, quarterly report in order to show more movements over a longer term. The results have also formed part of the Save the Elephants-South African's annual newsletter and presentations delivered at two conferences within this year where the USFWS contribution was acknowledged on both occasions. We have also reported our findings at the quarterly Joint Committee Meetings of the APNR.

The following detailed outputs relating to each dataset type are listed below:

<u>ID component and Elephant Tracking</u>

- *Musth signatures from GPS tracking data – do they exist?* (M.D. Henley, Addis, C., Henley, S.R., Ganswindt, A., Ganswindt, S., Wall, J. & Douglas-Hamilton, I. to be submitted to *PlosOne B*.)
- *Optimization of net returns from wildlife consumptive and non-consumptive uses by game reserve management.* (Emmanuel, M., Hearne, J., Stigter, J., De Boer, F., Henley, M.D. , Slotow, R., Van Langevelde, F., Peel, M., Grant, C.& Herbert, R. to be submitted to *Natural Resource Modelling*.
- *Hyperthermia risk couple solar movement to diel vertical migration in African elephants.* (De Knegt, H.J. Van Langevelde, De Boer, W.F., Shresta, A.K., Ovaskainen, O., J., Skidmore, A.K., Slotow, R., Henley, M.D., Grant, C.C., Knox, N.M., Kohi, E.M., Mwakiwa, E., Page, B., Peel, M., Pretorius, Y., Van Der Waal, C. & Prins, H.H.T. to be submitted to *Nature*).
- *An analysis of the performance of GPS collars used by Save the Elephant since 1998.* (White, S., King, L.E., Henley, S.R., Henley, M.D., Blake, S., Wall, J., Daballen, D. & Douglas-Hamilton, I. to be submitted to *Pachyderm*)
- *Developing individual based simulation models from tracking data to understand how animals forage for food in patchy landscapes across different seasons.* (collaboration with Prof. Prins, Wageningen University , the Netherlands)
- *Using remotely sensed vegetation indices to detect changes in vegetation characteristics and large herbivore spatial dynamics* (PhD by Yolandi Ernst from the University of the Witwatersrand)
- *Sexual segregation in African elephants, Loxodonta africana, in the Associated Private Nature Reserves, Limpopo, South Africa* (MSc by Tarryn Chapman from the University of the Witwatersrand)
- *Do anthropogenic and natural features act as barriers to African elephant (Loxodonta africana) space use?* (MSc by Kristy Robertson from the University of the Witwatersrand)
- *Genetics and landscape differentiation in elephants' movements* (Collaborative study between STE-SA, Princeton University, SANParks and WESSA)

<u>Tree monitoring project:</u>

- *Direct and indirect effects of elephants (Loxodonta africana) on large trees used by vulture and raptor as nesting sites, South Africa* (Vogel, S.M., Henley, M.D. Rode S.C., Van de Vyver, D., Meares, K.F., Simmons, G. & De Boer, W.F. submitted to *African Journal of Ecology*)
- Elephant impact on the nesting trees of vultures and raptors. (Roode, S., Henley, M.D. & Brown, L. Submitted to *Koedoe*)
- *Perceptions, protection and prevalence of elephant impact on large trees* (Presentation delivered by <u>Henley M.D.</u>, Derham K.., Edge A.C., Daday J. & Schulte B.A. at the Savanna Network Meeting of the KNP 2013.

- *Direct and indirect effects of elephants (Loxodonta africana) on large trees used by vultures and raptors as nesting sites* (Presentation delivered by Vogel, S.M, Henley M.D., Rode, S.C. van der Vyver, D., Meares, K.F., Simmons, G. & de Boer, W.F. at the Endangered Wildlife Trust's Birds of Prey Programme (BoPP) at Phalaborwa 2013.
- *Elephant impact on the large tree component and its potential effect on selected fauna* (MSc completed by Sieglinde C. Rode from the University of South Africa)
- *Impact of the African elephant (Loxodonta africana) on vulture and raptor nesting trees* (Final report by Susanne Vogel as part of the 6 ECTS Capita selecta program at the Resource Ecology Group of Wageningen University in the Netherlands. Score of nine with comments that no other students have achieved this grade before)
- *The impact of elephant browsing on vulture nest sites in Klaserie Private Nature Reserve, Limpopo Province, South Africa* (BSc (Hons) completed by Daniel van der Vyver from Rhodes University)
- *Effectiveness of wire netting in reducing impact by elephants to Marula and Knob Thorn trees in the Associated Private Nature Reserves, South Africa* (MSc by Kelly Derham of Western Kentucky University)
- *Elephants as important dispersal agents agents for Marula and Green Thorn seeds in the Associated Private nature Reserves, South Africa* (MSc by Katherine Gordon from the University of Cape Town)
- *Examining human perception of big trees and large elephants for insights into conservation of an African ecosystem* (BSc. (Hons) by Adam Edge from Western Kentucky University)
- *The effect of elephant feeding habits on nesting sites of vulture and raptors* (School Biology Project by Gabrielle Simmons submitted to the Intel Science Talent Search 2013 in the USA)

f) Cooperation and collaboration with local organizations

The northern Kruger Project's (Makuleke Concession Area) cooperation and collaboration with local organizations has been discussed in detail in the Final Report submitted to USFWS for the Grant (96200-9-G251). The Kruger East and APNR project has also involved many local organizations because of the extensive range over which the elephants moved which essentially involved two National Parks (KNP and LNP) situated in two different countries and several Private and Provincial Nature Reserves on the western border (Balule PNR, Klaserie PNR, Umbabat PNR, Timbavati PNR, Great Letaba Ranch, Manyeleti Game Reserve, and Sabi Sands Game Reserve). To this effect, all the individuals and organisations that have kindly provided support (financially or logistically), advice, elephant ID photos or data on various aspects of the project are listed:

South Africa:

- SANParks (Freek Venter-Specialist Head of Department Conservation Services, Sam Ferreira – Large Mammal Ecologist, Markus Hofmeyr – General Manager Veterinary Wildlife Services, Grant Knight – Chief Pilot Air Services, Sandra Visagie and field rangers– Section Ranger Pafuri, Sandra MacFadyen – GeoSpatial Analyst)
- Wildlife and Environmental Society of South Africa (Chris Galliers, Andrew Rossaak. Cindy Harper, Paul Bartels)
- The University of South Africa, South Africa (Leslie Brown, Alan Barret, Sieglinde Rode)
- The University of the Witwatersrand, South Africa (Norman Owen-Smith, Barend Erasmus, Neville Pillay, Francesca Parrini, Jason Mashal, Azhar Rajah, Kirsty Robertson, Tarryn Chapman, Catherine Nobrega and Yolandi de Beer)

- The University of Cape Town (Willem Bond, Catherine Bunney)
- The University of Pretoria, South Africa (Andre Ganswindt, Cindy Harper and Stefanie Münscher)
- The University of Texas (Colin Addis)
- Western Kentucky University (Bruce Schulte, Kelly Derham, Adam Edge)
- Kansas State University (Jesse Nippert)
- Wageningen University (Herbert Prins, Fred De Boer, Henjo de Knegt, Susanne Vogel, Emmanuel Mawakiwa, Cornelius van der Waal)
- Princeton University (Virginia Pearson, Matthew Aardema)
- Smithsonian Institution (Kari Morfield, Janine Brown)
- Wildlife vets for collaring operations (Dr. Cobus Raath)
- Elephants for Africa (Kate Evans)
- South African Observational and Environmental Network- SAEON (Tony Swemmer)
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- African Wildlife Tracking (Martin and Sophie Haupt)
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- The Peace Parks Foundation (Antony Alexander-Project Manager for LNP, Craig Beech – Information Systems Manager, Stefan Steenekamp – GIS specialist)
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<u>Mozambique – LNP:</u>

- Antony Alexander – Peace Parks Foundation Project manager appointed to LNP
- Antonia Abacar (Manager LNP) and Baldeu Chande – former Manager LNP)
- Valerio Macandza, Jason Marshal, James Cain, Joe Chirima (Ecologists who collared three elephants in LNP and who want to collaborate)

g) Cost, purchase date and use of equipment

Vehicle: 1999 Toyota Hilux 4x4 (Engine number 3RZ2086602)
Acquisition date: 2 June 2012
Cost: $ 8, 955.00 as USFWS contirbution (ZAR 64,789.42)
This vehicle, together with the other Toyota Hilux 1995 model purchased in November 2009 under Grant 96200-9-G251 represents the primary means of transport for this programme as the various study sites are considerable distances from each other. Thus far, the second-hand Toyota Hilux has proved itself to be reliable and effective under the demanding conditions to which it is exposed and used during daily field work.

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