SUMMARY

Various aspects of the conservation management of the elephants in Kruger National Park were investigated. The thesis covers most of the important aspects which may have influenced the population, starting with the early history of the population and finishing with a view to the future of the population under a new elephant management policy.

In contrast to previous historical accounts which suggested that elephants must have been abundant in the KNP area before the arrival of Europeans and their firearms, the evidence presented here, from a study of baobabs and a literature survey, suggested that this may not have been not the case. The evidence from baobabs was largely indirect but suggested that the prevailing abundance and population structure could not have been exposed to high densities of elephants (such as has occurred elsewhere in Africa) at any time during the life spans of the individuals currently in the population. The scarcity of elephants in the rock art of the San (Bushmen) in KNP compared to their popularity elsewhere in South Africa also suggests that these animals were rare during the San era. The earliest Europeans (de Cuiper) penetrated the KNP area in 1752 but found that the indigenous people they encountered did not consider the area as an "ivory area" but were told that ivory was plentiful in Zimbabwe. Later pioneers (Louis Trichardt and Joâo Albasini) could also provide no evidence of high densities of elephants. The writings of the later hunters show that those who hunted elephants did not do so in the KNP area, while those that did hunt there did not shoot elephants.

After the proclamation of the area as the Sabi Game Reserve and later the Kruger National Park, the elephant population increased unchecked and recolonisation of the entire area occurred. This process is documented and recolonisation rates estimated. Elephants were recorded for the first time in the central area of KNP in 1905, and the recolonisation process took until 1945 to reach the northern boundary and to 1958 to reach the south-western corner. The growth of the population up to the implementation of management actions is reviewed.

Management in the form of fencing and culling was initiated in the 1960's. The management policy of the time is reviewed. The census and culling techniques are described and evaluated. The census technique has remained standardised since 1967. The estimates of the census' precision ranged between 12.1% and 7.3% of the expected result. Culling techniques changed from the use of the compound scoline (succinylcholine chloride) to shooting with a heavy calibre rifle, as scoline was shown to cause death through asphyxiation, which is considered inhumane.

The policy's objective was to maintain the elephant population at around 7 000. The history of management under this policy is recorded. The numbers of elephants removed in this process between 1967 and the present was between 16 and 1 846 annually, making up a total of 16 520 elephants.

The observed rate of increase ($\bar{r}$) of the population was estimated from the annual census results. Annual estimates of $\bar{r}$ showed a declining trend which is thought to be related to fencing. The last of KNP's boundaries was fenced in 1976 and between 1967 and 1976, the mean $\bar{r}$ was 0.104, the high value resulting from immigration from Mozambique. Between 1976 and 1994 the population was confined and the mean $\bar{r}$ was 0.066. This is regarded as the natural rate of increase as it was not influenced by immigration or emigration. The western boundary fence was removed in 1994 and between then and 2000, $\bar{r}$ declined further to 0.015. This is thought to result from emigration to the private reserves to the west.

The mean calving interval (MCI) was calculated at 3.99 years from the respective proportions of pregnant and non-pregnant cows examined at culls. Cull data also allowed an estimate of the proportion of breeding cows in the population. These two estimates in turn allowed an estimate of the potential rate of increase of 0.098, which is the rate of increase if no mortalities were to occur. The difference between the observed and potential rates of increase gave an estimate of the mean annual mortality of 3.2%.

Movements of 29 adult elephants were studied using radio telemetry. Home ranges were determined for both 100% Minimum Convex Polygons (MCP's) and 90% MCP's. The

recorded home ranges (100% MCP's) varied in size between 86 km^2 and 2 776 km^2 with a mean of 880 km^2, while the 90% MCP's ranged from 45 km^2 to 1 805 km^2, with a mean of 523 km^2. Some of the cows occupied very similar ranges and were probably of the same "clan", but the 90% MCP's showed distinct separation of other cows who were clearly from different clans. Movements suggested that these cows have a high degree of fidelity to their home ranges and that although movements may be induced by the disturbance of culls, they do not leave these ranges. This allowed the designation of boundaries of management zones in the new elephant management policy between these home ranges, as it is expected that these will be maintained once this new policy is implemented.

Aerial censuses provided data for an analysis of culling on the dynamics of the population. The KNP was divided by management into four zones. A full year's cull was taken from one of these zones per year on a rotational basis. Responses of sub-populations in these zones were monitored to determine how post-culling densities affect population growth rate. The analyses suggest there may be an alternative management strategy for the elephants in KNP. From these analyses it appears that numerical changes in elephant sub-populations in KNP are density dependent. At densities >0.374 elephants/km^2 the population tended to decrease, i.e. that in KNP density dependence of population growth rate only starts operating at densities greater than 0.37 elephants/km^2. This density is equivalent to an elephant population of very nearly 8 000 for KNP, and was thus within the limits set for the population by earlier KNP managers. However, these analyses were conducted on the sub-population level and changes in population size for a given region may have resulted from intra-population movements rather than changes in demographic variables.

In the wake of the moratorium placed on culling in KNP since 1994, contraception research was encouraged as a non-lethal means of population control. The dilemmas of elephant management were presented and a spreadsheet model was developed to investigate the logistics of a contraception operation. This showed that to ensure zero population growth, the average calving interval would have to be reduced to about 12 years,

or about 75% of all cows >12 years. In KNP this equates to about 2 250 cows which would have to be under treatment. Furthermore, a zero population growth rate would only be attained after 11 years of treatment because in that 11-year interval, females born before the use of the contraceptives would steadily be recruited into the breeding population. The final management effort would require ≅ 4 000 animals to be under treatment. Through the model, a numerically simpler means of limiting population growth was identified. The killing or sterilization of 250 pre-breeding cows would achieve the same goal.

An assessment of two contraception techniques was made. The methods were the "immuno-contraception" method using porcine zona pellucida immuno-contraceptive vaccine (pZP), and hormonal control through surgical subcutaneous insertion of oestradiol-17ß implants. These techniques each had certain potential problems associated with them such as social disruption, threats to the health and welfare of the treated animals and/or their calves, and behavioural aberrations. The oestradiol treatment proved unacceptable to managers for various reasons. A state of false oestrus was experienced by treated cows resulting in harassment by bulls. This caused separation of the cows from their calves and matriarchal groups. Three calves from the 10 treated cows disappeared while none disappeared from the pZP treated group. Contraception was achieved but treated cows appeared to have been permanently sterilised. The pZP program achieved some successes and no behavioural problems were observed. This method holds promise for smaller populations.

The process of developing the new elephant management policy is recorded and the new policy presented. This policy defines six management zones in KNP. Two of these are botanical reserves where rare plants and plant communities are to receive management priority. The elephant populations of two of the remaining zones (low-impact zones) are to be reduced annually by 7% to induce a gradual decline. In the final two zones (high-impact zones), no management will take place, and it is anticipated that numbers will increase at the observed rate of increase of around 7% per year. The expectation is that both the high and low densities induced in these respective zones will ultimately have negative consequences for biodiversity. Changes will be monitored through a biodiversity

monitoring program. Acceptable limits to these changes will be set in the form of "Thresholds of Potential Concern" (TPCs). Should one or more of these be reached or exceeded, the prescribed management option will be reversed and low-impact zones will become high-impact zones and *vice versa*. Population trends under this new policy were modeled, showing that numbers to be removed from the population decline, while the population itself increases. After a TPC is reached, numbers to be removed will increase dramatically but decline again over time, while populations decline initially but will then enter a phase of increase again. Numbers and time scales are dependent upon when and at what elephant density the TPC is reached.

A personal evaluation of this new policy is presented.