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WEAVER, STEPHEN MARK

HABITAT UTILISATION BY SELECTED HERBIVORES IN THE KLASERIE PRIVATE NATURE RESERVE, SOUTH AFRICA

MSc (WILDLIFE MANAGEMENT) UP 1995

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HABITAT UTILISATION BY SELECTED HERBIVORES IN THE KLASERIE PRIVATE NATURE RESERVE, SOUTH AFRICA

by

Stephen Mark Weaver

Submitted in partial fulfilment of the requirements
for the degree of

MSc (Wildlife Management)

in the
Centre for Wildlife Management
Faculty of Biological and Agricultural Sciences
University of Pretoria
Pretoria

Supervisor: Prof. J. du P. Bothma
Co-supervisor: Prof. G. K. Theron

June

1995

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CENTRE FOR WILDLIFE MANAGEMENT

FACULTY OF BIOLOGICAL AND AGRICULTURAL SCIENCES

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ABSTRACT

A study of selected herbivores on the Klaserie Private Nature Reserve, Eastern Transvaal lowveld, was done to investigate habitat relationships as a means to develop optimum stocking rates in line with the mean carrying capacity. Use patterns for eight types of herbivore are analysed and compared with quantitative botanical data collected by the, then, Transvaal Provincial Administration (TPA) and subjected to CATMOD analysis. Guidelines for stocking rates and habitat monitoring are given.

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ACKNOWLEDGEMENTS

I wish to acknowledge the Grace of our Lord and Saviour Jesus Christ humbly, that He has enabled me to be what I am. I pray that this work will reflect, in some small way, the glory of His creation and contribute positively to its proper stewardship.

Sincerest thanks are due to Mr. & Mrs. E. Leibnitz for their assistance and friendship. The owners of the Klaserie Private Nature Reserve are also thanked for their kindness and generosity in designating me as the first recipient of the Paul Mouton study bursary and their giving me considerable material and moral support. I'd like to thank Dr. H. Nel, particularly, for providing accommodation and needed botanical expertise. The Mazda Wildlife Fund is acknowledged gratefully for their donation of a light truck for the 1991-1992 study period. This donation made a vital difference because of the dependability, versatility and economy of the unit provided. Gold Fields Foundation provided a bursary at a critical time and Leupold and Stevens, Inc. USA, provided necessary optical instruments.

My wife Kathleen deserves more than thanks for her tolerance, assistance in typing data and translation of the summary into Afrikaans.

Mr. and Mrs. Hans Wellman are thanked for their hospitality in

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letting me monopolize their computer during the final write up, as well as several notable Braai's

The Foundation for Research Development, and the University of Pretoria, are also thanked for their financial assistance in 1990-1991. Those associated with the University of Pretoria who deserve special thanks include. Dr. Mike van der Linde of the Department of Information and Technology for his untiring optimism, ingenuity and helpfulness. Prof. H. T. Groeneveld of the Department of Statistics for his keen insights into statistical relationships and unraveling them for a biologist's mind.

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CHAPTER ONE: INTRODUCTION

Private wildlife reserves are conceived and run for a variety of reasons which generally centre around a human desire to be near wildlife in a "natural" setting. Such reserves may practice consumptive utilisation or be run for purely aesthetic purposes. One factor that all such reserves have in common is the need to balance wildlife species numbers and diversity under habitat situations which have been altered greatly by man. Even the largest nationalised reserves are seldom of sufficient size to be ecologically stable units (Eltringham 1979). In tandem with this problem is the need to function within the economic realities of the day (Pienaar 1983). Few, if any, reserves have the luxury of an unlimited budget. Therefore artificial feeding is seldom a viable concept. The alternative, then, is management of the habitat to obtain the desired goals in an economically and ecologically viable manner. Certainly this is the case on reserves occupying large areas. An author such as Stroleny-Ford (1990) has further emphasised the need to consider the economical aspects of carrying capacity. Thus both ecological and economical capacities must be considered when setting up wildlife management proposals for any given area.

The term carrying capacity has essentially been borrowed from the agricultural vocabulary, and can differ substantially when applied in the husbandry of wild herbivores (Eltringham 1979).

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In the agricultural sense the carrying capacity, or grazing capacity as it is now mostly called, is defined broadly as the maximum number of animals that can graze a given area of land on an annual basis without damage to the land. Thus the level of use is kept within the parameters maintaining forage quality, total production or soil quality (Stoddart, Smith and Box 1975). This is best applied on an ecological basis for wildlife species (Crawley 1983), as opposed to the more absolute values involved in the agricultural definitions.

When only one herbivore species is concerned the carrying capacity is relatively easy to determine. The interplay of grazers, browsers, and especially mixed feeders on areas such as the Klaserie Private Nature Reserve add an additional factor to the determination of carrying capacity. Two clear capacities, then, come into play; i.e.: the grazing and the browsing capacity with a grey area provided by mixed feeders such as the impala . These two capacities are not pure unto themselves, but tend to overlap in varying degrees, dependent upon the type of herbivore involved and the season of the year (French 1985).

The best means of achieving ecologically and economically viable habitat management is the institution of a well-planned approach based on accepted range and wildlife management practices (White 1987). Any such approach must acknowledge the importance of carrying capacity and stocking rates. Although these terms are

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variously defined, McCullough (1984) suggests that carrying capacity be defined as "the maximum number of animals an environment will support on a sustained basis (that is without destruction of the vegetation)." This has been further refined by Bothma (1989) as a function of the ecological ability of a given area. This is the definition that is used here. The optimum stocking rate for a particular species in a given area and at a specific point in time will quite probably differ from its ecological capacity. Such an optimum stocking rate has been defined as a percentage of the ecological capacity (Trollope 1990). Within these understood parameters stocking rates, by species, should be regulated primarily by the management objective(s) of the area (Bothma 1989). It is understood in this context that carrying capacity will fluctuate with climatic variations. Further, it is understood that carrying capacity is not an absoloute, but rather a dynamic term when applied to any herbivore population. Thus any increase in natality, mortality, immigration or emigration will affect the carrying capacity and necessitate its periodic revision (Walker 1976).

Since the inception of this study the very term, carrying capacity, has fallen from favour in many instances. However, in defining this study the term was used in the basic approach. Carrying capacity, then, is used here within the context of its evolving meaning and with specific reference to the situation on the Klaserie Private Nature Reserve (Figures 1 and 2).

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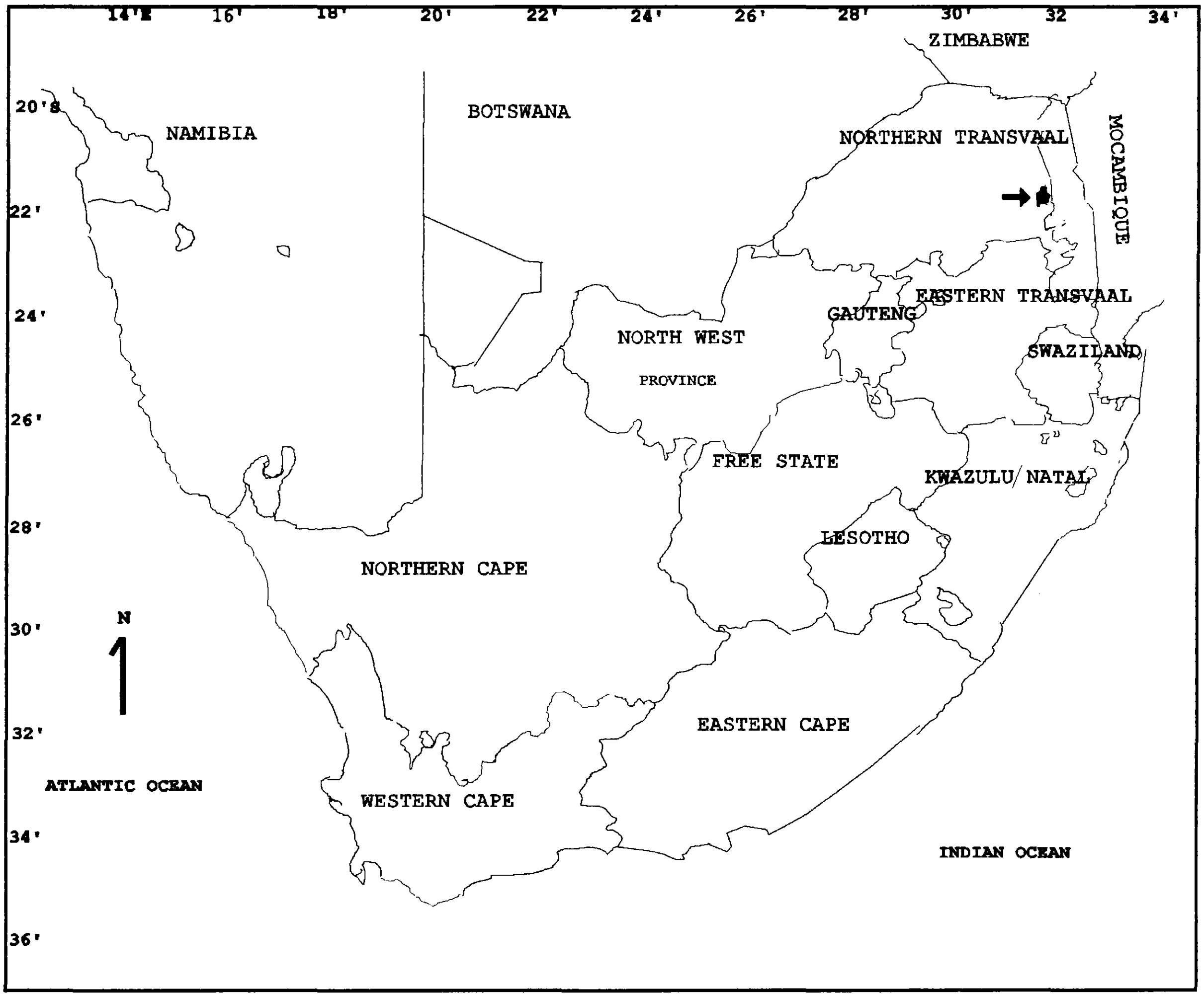

Figure 1: Location of the Klaserie Private Nature Reserve (arrow, black area) in the Eastern Transvaal Province, Republic of South Africa.

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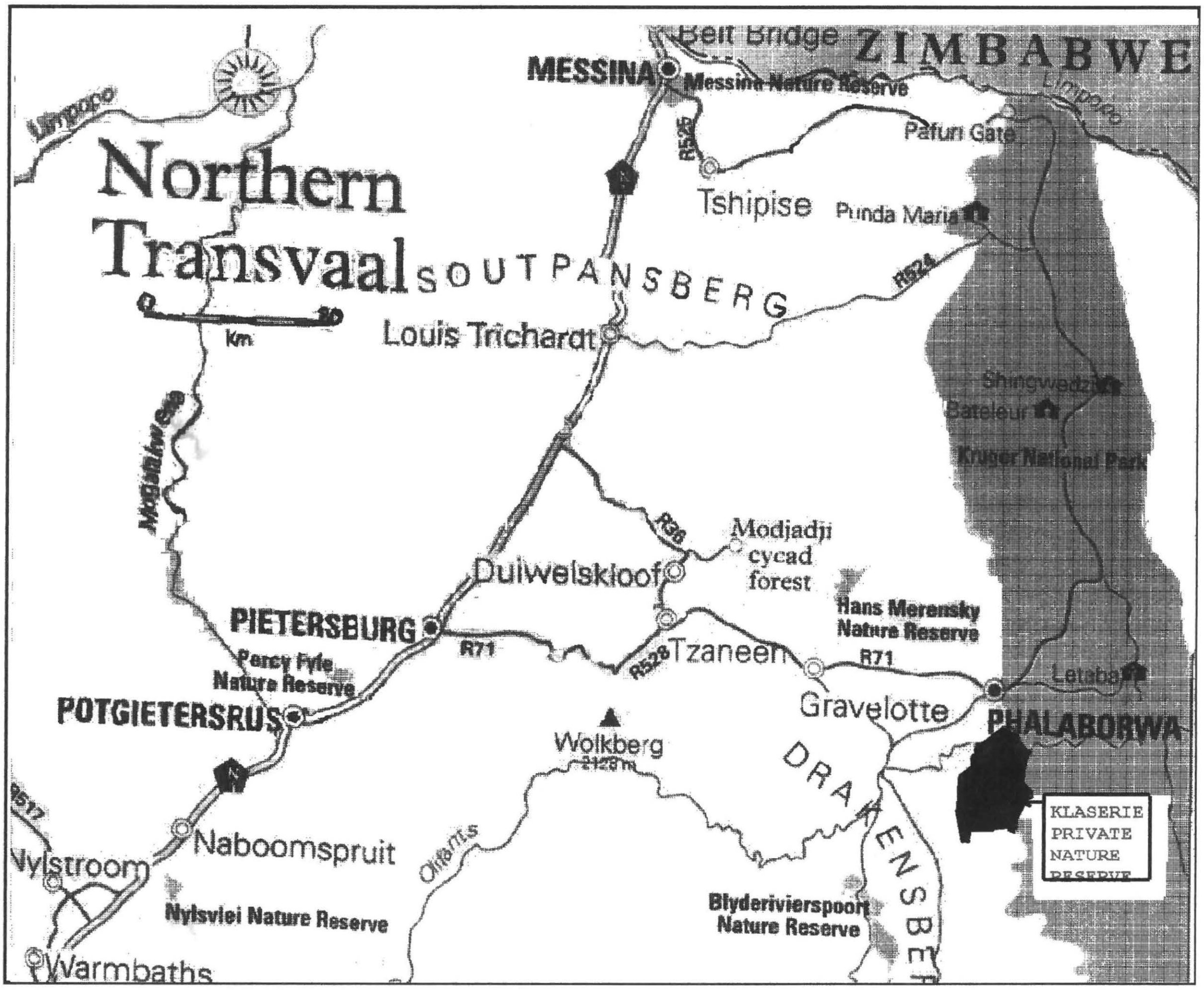

Figure 2: Location of the Klaserie Private Nature Reserve, adjacent to the Kruger National Park in the Northern Transvaal Province, Republic of South Africa

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HISTORY OF THE KLASERIE PRIVATE NATURE RESERVE

The Klaserie Private Nature Reserve currently consists of 65 privately owned properties which have been run jointly as a nature reserve since proclamation on 26 January 1972. At that time all internal fences were removed and the adoption of a constitution began a unitary management policy including the elimination of all internal fences. Since inception the reserve has gone through a major drought (1981-83) and suffered habitat degradation from subsequent over-stocking. This effect was cumulative, with historical livestock abuse on portions of the reserve occurring prior to its proclamation. Beginning in 1993, boundary fences between the Klaserie Private Nature Reserve and adjacent areas of the Kruger National Park, and the Timbavati Private Nature Reserve were removed (Figure 3). This is the natural conclusion of the process which began in 1972 and further complicates the current management of the habitats on the reserve.

A large-scale erosion control programme was begun on the reserve in 1988 and has already resulted in the reclamation of some of the drought-impacted areas. Bush clearing is another relatively new endeavour with an ongoing status. Although game has been consistently present on the Klaserie Private Nature Reserve throughout historical times, the types and density of the animals have altered considerably due to changing ownership and

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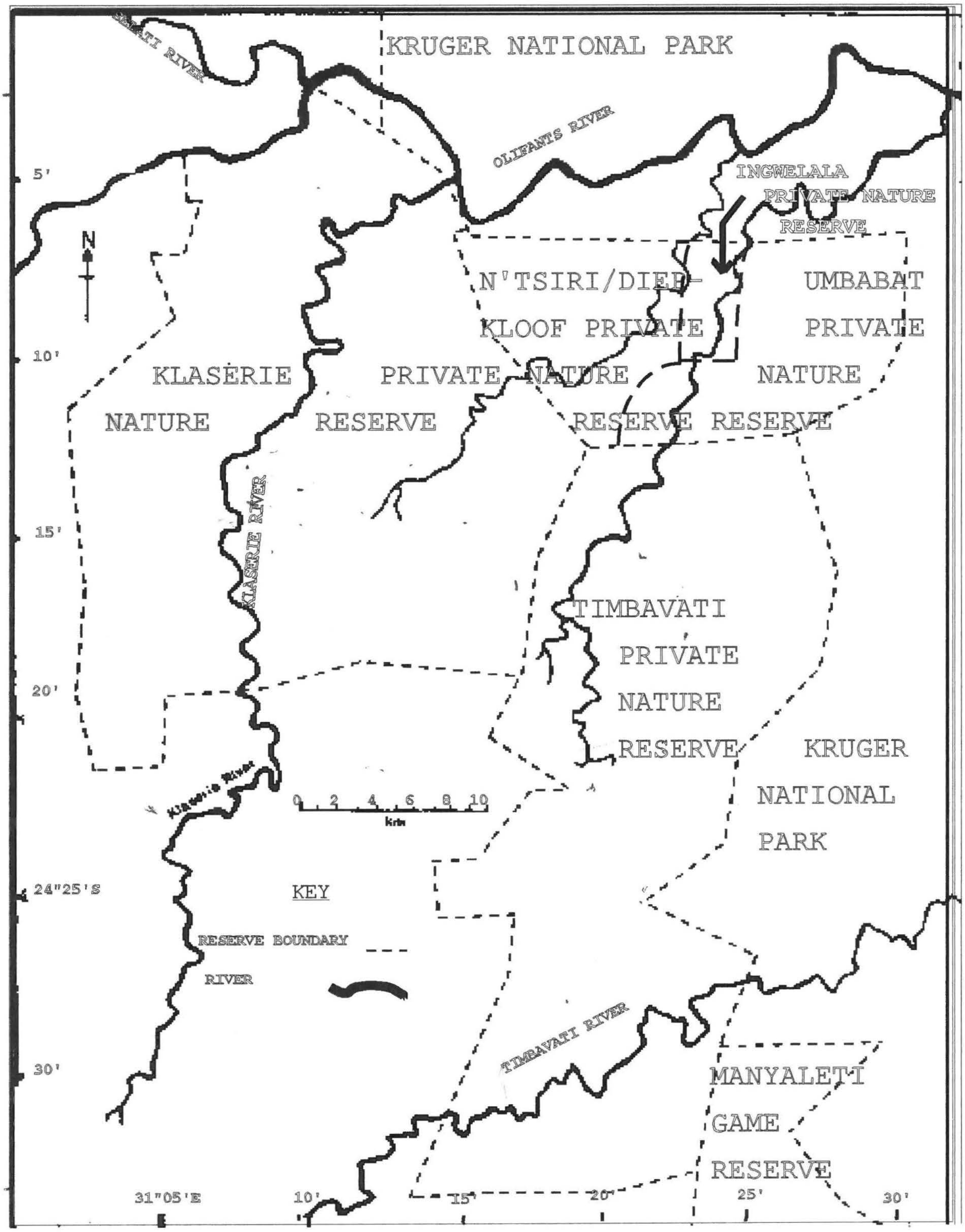

Figure 3: **The Klaserie Private Nature Reserve, relative to other private reserves and the Kruger National Park, Northern Transvaal, Republic of South Africa**

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management strategies. Such changes in use density are not without precedent (Blankenship and Field 1972). A lack of water and fences, traditionally, made the area that is now the reserve a seasonal use area in conjunction with annual migration from lowveld habitats to the adjacent higher elevations of the Drakensburg Mountains. In the past the Klaserie River corridor was most heavily impacted on by herbivores. The areas on either side of the river corridor were used heavily with the degree of game utilisation decreasing in direct proportion to distance from the river. This situation altered drastically with the introduction of artificial water points and fencing (Zambatis 1982). The recent removal of most boundary fences has again altered the distribution of herbivores with as of yet unquantified results.

It has been reported that sable antelope Hippotragus niger were shot for staff rations on large areas of what is now the reserve throughout the 1940's (Gillatt, pers. comm.*). It has also been reported that elephants were rare into the early 1950's. Impala were also known to be absent from most of the reserve in the 1930's and 1940's (Crookes, pers. comm.**).

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* : Mr. I.F.G. Gillatt, P.O. Box 935, Stanger, 4450

**: Mr. A.C. Crookes, P.O. Box 11, Highflats, 4640 (Now deceased)

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No doubt some of these alterations were due to human influence. However, others would appear explicable only in a habitat perspective.

PAST RESEARCH

There has been an awareness of the need for sound management and, consequently, of site specific research since early in the history of the reserve. As a result research has been an ongoing activity in the reserve. Aside from multiple visits of relatively short duration by experts to address specific problems, more formalised research has been done by several individuals.

One of the early comprehensive studies was done by the then Nature Conservation Division of the Transvaal Provincial Administration (Zambatis 1982). This study addressed the proliferation of man-made waterholes on the reserve and their implications to habitat management. Additionally a compilation of habitat surveys on the reserve was put together as part of an ecological survey of the Eastern Transvaal lowveld (Zambatis 1985). Two ecologically oriented studies were done in 1983, one dealing with climate and stocking densities (Schneebeli 1983) and the other with the overall ecology of the reserve (Witkowski 1983). The Klaserie Private Nature Reserve supplied some of the study sites in a 1984 study of seepline grassland widths (Olbrich

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1984). A study on the effects of bush clearing on the savanna habitats was completed (Scholes 1987) and a study of carnivore interrelationships was done by Kruger (1988).

Recent vegetative data collection has also been done by the then Chief Director of Nature and Environmental Conservation of the Transvaal Provincial Administration (De Villiers, pers. comm.*). Consistent records have also been kept on animal numbers, mortalities, natalities and precipitation since the mid 1970's.

PRESENT SITUATION

Currently the Klaserie Private Nature Reserve accommodates a wide variety of indigenous animal species. Attempts to increase this have been made with varying degrees of success. The white rhinoceros <u>Ceratotherium simum</u> was reintroduced successfully into the reserve in 1977 and 1979. The population is slowly increasing, although it suffered a setback in the 1983 drought. Nyala <u>Tragalaphus angasii</u> are another examples of success. The management directive for the reserve is to continue introductions of indigenous species to the extent that it is determined that they have a reasonable chance for success.

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*: Mr. P. A. De Villiers, Eastern Transvaal Provincial Administration, Department of Environmental Affairs, P.O. Box 1232, Nelspruit, 1200 (Now Retired).

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The introduction of alien flora and fauna is actively discouraged. It is recognized by the reserve management that the habitat is a dynamic entity requiring intensive management within its artificial restraints.

Imparting this awareness to the many owners and members of the reserve, and obtaining a clear consensus for a management mandate is another matter entirely. Clear and well-defined research and its subsequent products can be important factors in achieving this goal. Indeed, research in and of itself is of little use unless it can be implemented on-the-ground (Eltringham 1979).

CURRENT STUDY

The current study was begun to gain a better understanding of herbivore/habitat interactions on the Klaserie Private Nature Reserve. The reason for this was the need for an ecologically and economically viable, long-term management plan. Target herbivores in the current study initially included: elephant Loxodonta africana, impala Aepyceros melampus, Cape buffalo Syncerus caffer, kudu Tragelaphus strepsiceros, blue wildebeest Connochaetes taurinus, Burchell's zebra Equus burchelli, white rhinoceros Ceratotherim simum, giraffe Giraffa camelopardelis and warthog Phacochoerus aethiopicus. These were selected because of their known utilisation of different habitat components and as likely indicators of habitat condition and degree of

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ecological separation. The white rhinoceros was later dropped from consideration due to its low numbers and the subsequent statistical irrelevancy of the data gathered on it.

Vegetation data collected by the erstwhile Transvaal Provincial Administration suggested the presence of 14 variations (vegetation types) of 8 major vegetation associations on the reserve (Chapter 2)(Zambatis 1983). Representative transects of about 30 km each were established in each of the 14 variations. The erstwhile Transvaal Provincial Administration has subsequently gathered quantitative data specific to each of these types. As a result quantitative vegetation data were not gathered at each observation in the course of the current study, rather the broad aim of the study was to determine precise habitat utilisation patterns for each chosen type of herbivore.

Currently the Klaserie Private Nature Reserve is carrying only a portion of the indigenous herbivores known to have occupied the area in historical times. Conversely, the herbivore biomass is undoubtedly much higher than in historical times. This latter development is a function of the ubiquitous water supply now present on the reserve. Research to date indicates an increasing potential for bush encroachment and a trend toward the loss of tall grass grazers such as the sable antelope. Missing indigenous game, with the exception of the black rhinoceros, are those with requirements skewed toward the more open savanna

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types. An optimum future condition, as envisaged by the owners and management, would be a correction of some of these negative trends, while increasing the diversity of indigenous game, decreasing bush density and maintaining an optimum stocking level for all species. This approach was used as a basic reference framework for the current study.

DISCUSSION

Given the known changes in habitats, herbivore biomass and herbivore use of habitats on the Klaserie Private Nature Reserve within historical times it is reasonable to hypothesize that a study of current use by herbivores would yield data relevant to management of these habitats and specific vegetation types. Various studies in and around the Klaserie Private Nature Reserve have proven this, Wentzel(1989) recently showed the value of such work in adjacent areas of the Kruger National Park. Kruger (1988) showed the value of species specific observations on the Klaserie Private Nature reserve. Utilising accepted methodologies for such observations and adapting them specifically to the habitats and species being observed should yield data relevant to proper management. The following objectives were devised to test the this hypothesis within the context of the Klaserie Private Nature Reserve.

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Objectives:

* The determination of the distribution and habitat preferences of the major types of herbivore in relation to each other (ecological separation) and in relation to the vegetation types of the reserve.

* The determination of the carrying capacity of the different habitat types in relation to the existing numbers of herbivores, and the determination of any trends in habitat quality.

* The suggestion of habitat improvements to increase carrying capacity.

* Assessment of the potential for introducing extirpated herbivores, specifically tsessebe Damaliscus lunatus, roan antelope Hippotragus equinus, and black rhinoceros Diceros bicornis.

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CHAPTER TWO: THE STUDY AREA

The Klaserie Private Nature Reserve is unique by virtue of its size and location (Figure 1). It is possibly the largest private reserve in the Republic of South Africa, if not on the continent of Africa (Ebedes, Vernon & Grundlingh 1991). Certainly it is the largest such reserve in the Eastern and Northern Transvaal lowveld (Figure 2 & 3). By virtue of this size (62 818 ha), it encompasses a variety of lowveld habitats with varying ecological capabilities.

PRE-HISTORY

It is likely that the area which is now the Klaserie Private Nature Reserve was used migrationally, on a seasonal basis, by indigenous herbivores prior to European settlement. The majority of such use probably occurred in a band along the Klaserie and Olifants River corridors (Gertenbach, pers. comm.*). Surface water was scarce and likely the significant limiting factor to herbivore use of the area during the dry season on that part of the Reserve outside of the Klaserie River's influence.

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*: Dr. W.P.D. Gertenbach, Kruger National Park, Private Bag X402, Skukuza 1350

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Year-round herbivore impacts on most of the current Klaserie Private Nature Reserve habitats and plant communities, prehistorically, was likely only in association with such a supply of permanent river water.

Archaeological evidence suggests a long standing human presence during much of the last millennium centring around iron smeltering operations immediately to the north of the current Klaserie Private Nature Reserve in what is now the town of Phalaborwa. At least one archaeological site exists on the Olifants River section of the reserve (Leibnitz, pers. comm.*). It is reasonable to assume there was some use of what is now the Klaserie Private Nature Reserve for hunting and gathering purposes commensurate with the early human presence at the current Phalaborwa. Pottery shards of bantu origin were discovered in the southern sections of the study area during the course of this study, confirming some prehistorical presence on what is now the Klaserie Private Nature Reserve (Ueckermann, pers. comm.**)

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*: Mr. E. P. Leibnitz, Warden, Klaserie Private Nature Reserve, P.O. Box 150, Hoedspruit, 1380

**: Miss M. Ueckermann, Vintage street 9, Alphenpark, Benoni, 1501

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RECENT HISTORY

Other than transient hunting by European man late in the previous century (Stevenson-Hamilton 1929), the area that now encompasses the Klaserie Private Nature Reserve was used primarily as an area for livestock grazing beginning after the end of World War I. Use of what is now the Klaserie Private Nature Reserve by cattle is confirmed from the 1930's. Sport hunting has, however, played a constant and prominent role in the use of this area throughout recorded history. Beginning in the middle 1930's land purchases in the lowveld began to be less commercialised and started reflecting increased interest in consumptive conservation (Leibnitz, pers. comm.*).

Through the 1950's seasonal herbivore use of the study area continued, with a summer migration of wildlife from the Kruger National Park. This was notably animals such as the blue wildebeest and zebra were observed in large herds. A return migration to the east was commensurate with the drying of waterholes and forage about two to three months later. Such seasonal use by grazing animals was largely curtailed with the construction of a fence between the Kruger National Park and the private lands to the west in 1961 (Witkowski 1983).

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*: Mr. E. P. Leibnitz, Warden, Klaserie Private Nature Reserve, P.O. Box 150, Hoedspruit, 1380

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The fence was removed in 1993, again allowing free movement of game to and from the adjacent Kruger National Park.

Most of what is now the Klaserie Private Nature Reserve was originally purchased by the Crookes family of the then Natal (Crookes, pers. comm.*). The Crookes' were predominately sugar farmers but saw a value in purchasing the lowveld lands for grazing and sporting purposes, until such time as the land prices reached near one pound per morgen. After that point they began to sell the properties slowly. The Crookes family still retains property in the west and southwest of the Klaserie Private Nature Reserve on the farms Kent and Northampton (Figure 4).

The use of the area by livestock farmers began a process which has no doubt altered the native vegetation. Since the inception of the reserve, game fencing, perennial stocking, fire exclusion, and the establishment of multiple, well-dispersed, water sources have undoubtedly accelerated this effect on the encompassed habitats. Larger numbers of herbivores for game viewing were desired by reserve members and attainment of such numbers was possible primarily because of water developments. Herbivore numbers generally increased from 1972 until 1980 due to the above reasons and a period of above average rainfall (Witkowski 1983).

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*: Mr. A. C. Crookes, P.O. Box 11, Highflats, 4640 (now deceased)

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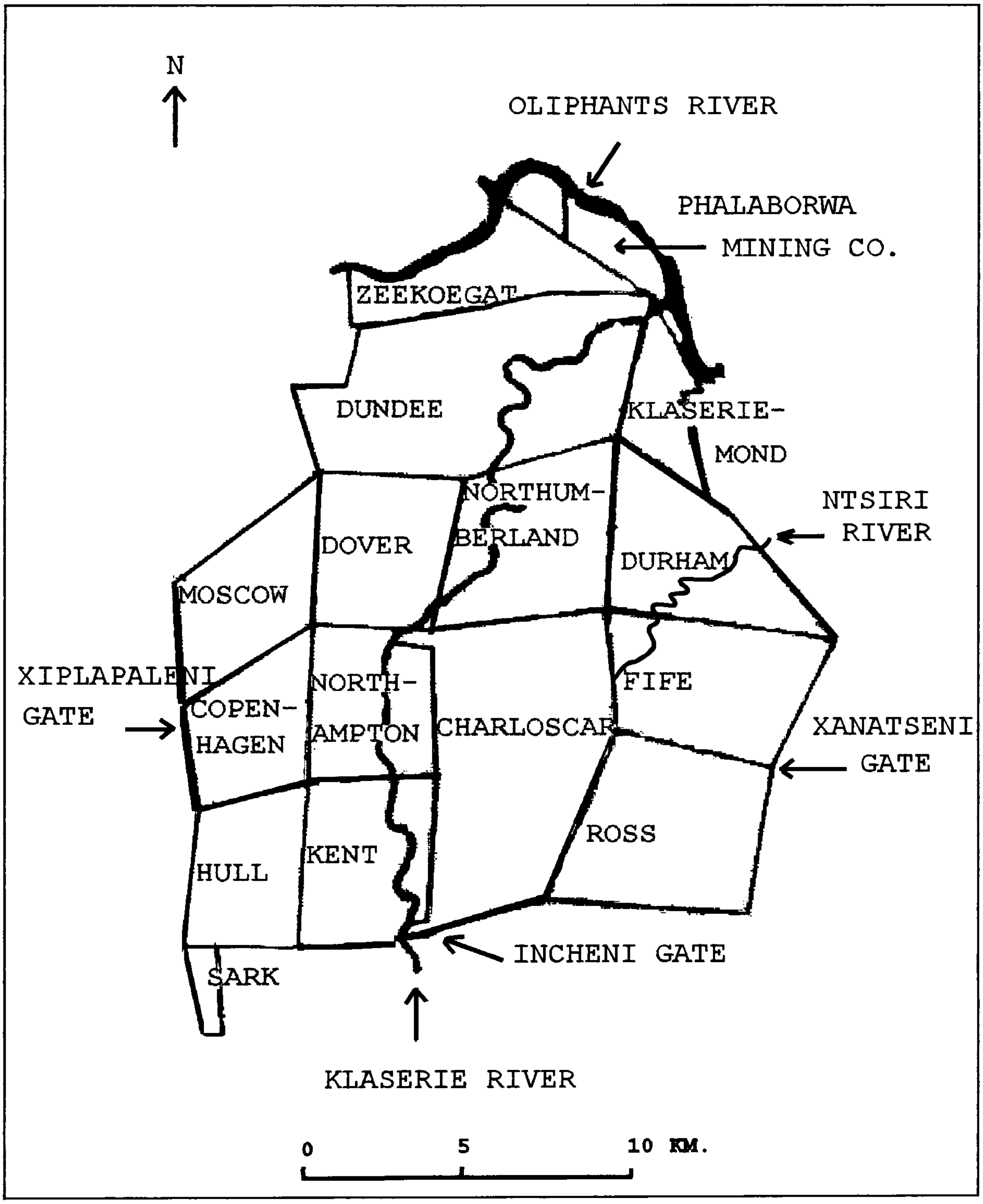

Figure 4: The Klaserie Private Nature Reserve showing the major legal (old farm) divisions.

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During the drought years of 1981-1983 herbivores exceeded the carrying capacity of the standing plant biomass. This resulted in a substantial die-off of herbivores with unquantified deleterious effects on the grazing component vegetation (Schneebeli 1983). Denuded habitats, particularly in the southern end of the reserve, eroded severely during the following 1984-1985 wet period (Scholes 1987). Lighter stocking rates and erosion control projects have since mitigated this effect to some degree.

LOCALITY

The Klaserie Private Nature Reserve currently consists of 65 privately owned properties which have been run jointly as a nature reserve since proclamation in 1972. The surface area of the Klaserie Private Nature Reserve is 62 818 ha and the reserve is situated in the Eastern Transvaal lowveld. It lies between 31° and 03' E and 31° 18' E and between 24° 22' S and 24° 03' S. It is bordered on the north by the Olifants River, the Phalaborwa Mining Company and the Kruger National Park on the north and northeast (Figure 3). It was separated from the latter by a 2,5 m. tall, non-electrified game fence from 1961 until 1993.

The purpose of this fence was one of foot-and-mouth disease control, but its effectiveness was dubious as the barrier qualities of the fence varied. During the course of the study

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it was observed as being only a minor hindrance to animals such as elephant or warthog. Impala were observed challenging the fence with a considerable degree of success. On the other hand waterbuck <u>Kobus ellipsiprymnus</u> had great difficulty in negotiating it. It was, substantially, a total barrier to zebra and blue wildebeest.

The Klaserie Private Nature Reserve was never separated physically from the Phalaborwa Mining Company property or the Olifants River. In the east and southeast a non-electrified game fence separated the Klaserie Private Nature Reserve from several small private holdings and the larger Timbavati Private Nature Reserve until the fencing with the Timbavati Private Nature Reserve was also removed in 1993. The barrier qualities of this fence were similar to those described above for the Kruger National Park. Currently, the remainder of the Klaserie Private Nature Reserve is separated from other, small, private holdings by a 2,5 m. electrified game fence to greater exclusionary effect.

PHYSIOGRAPHY

The Klaserie Private Nature Reserve is flat to gently undulating with a general slope from the southwest to the northeast. The northern third of the reserve is more hilly with rock outcrops there being more common than on the southern two-thirds. The

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altitude ranges from 303 to 535 m above sea level. The major drainage is the Klaserie River which flows northeast through the reserve. The southeast section of the Klaserie Private Nature Reserve is drained by the Ntsiri River. Both the Klaserie and Ntsiri Rivers drain into the Olifants River outside the Reserve boundary (Kruger 1988). The Ntsiri River is seasonal over its course within the reserve, but the Klaserie River is perennial. However the latter's flow is considerably reduced from historical times due to the Jan Wasenaar Dam near the town of Klaserie. Large stretches of the river, within the reserve boundary, are now subterranean during the dry season. This is particularly true as the river nears the confluence with the Olifants River.

Parent materials on the reserve are predominately granites and gneisses. Soil depths vary considerably throughout the reserve with upland and northern portions tending to be coarse, stony and shallow. Southern and non-sloping areas generally tend to be deeper, clayey and more capable of holding water. Seeplines, where they occur, are dominated by grasses and are generally identified by an upslope band of Terminalia sericea. Bottomland soils are interspersed with sodic areas which attract herbivores often resulting in over-utilisation and subsequent erosion. This was a particular problem in southeast sections of the reserve after the 1981-1983 drought (Witkowski 1983).

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CLIMATE

The climate is typified by a summer wet season roughly confined to the months of October through April, with the bulk of precipitation occurring between November and March. The remainder of the year tends to be dry with rare occurrences of precipitation. Temperatures tend to be relatively high with frost extremely rare and snow never having been recorded historically. Temperature data collected by the Klaserie warden from 1975 to 1991 indicated a mean daily maximum temperature for the wet season (October-March) of 32,6° C and a mean daily minimum temperature of 20,5° C. Mean temperatures for the dry season (April-September) were 28,4° C for the mean daily maximum and 10,8° C for the mean daily minimum (Kruger 1988).

Annual evaporation rates exceed mean annual precipitation rates (Scholes 1987). Generally the reserve falls within the 500 mm isohyet (Gertenbach 1980). Mean annual precipitation on the reserve as recorded by Kruger (1988) is 415,5 mm. Mean figures can be misleading, however, in that precipitation events tend to be highly localised in the lowveld. Rainfall recorded during the course of this study at the base camp on the farm Ross was 389,3 mm in 1990-91 and 139,5 mm in 1991-92. Figure 5 illustrates annual rainfall variations on the Klaserie Private Nature Reserve from 1981 through 1991, after Peel (1992).

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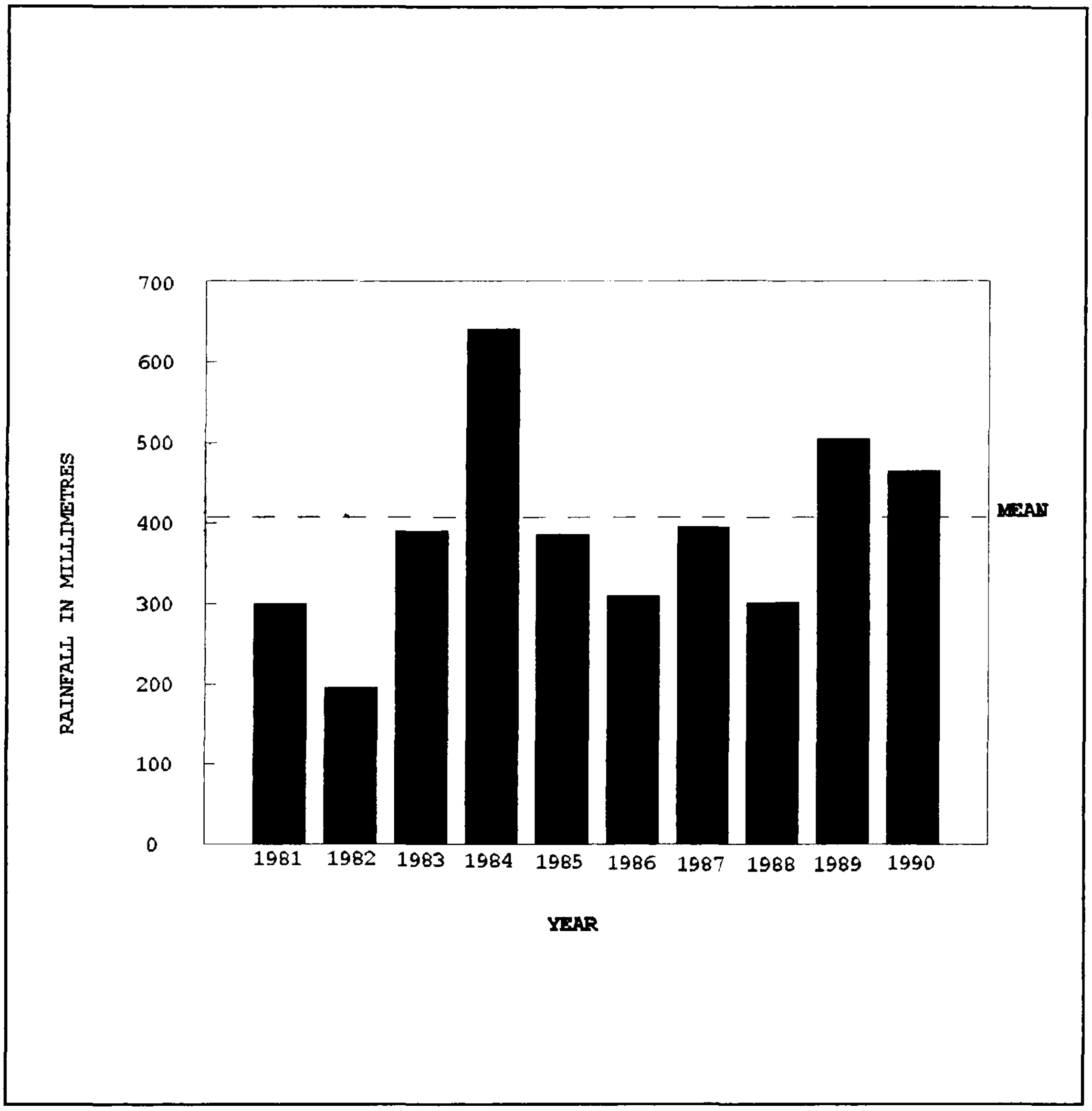

Figure 5: Annual rainfall for the Klaserie Private Nature Reserve for the years 1981-1991. Year indicated in figure is beginning of wet season year, thus 1981=1981-1982. Data is after Peel (1992), Agricultural Research Council, Roodeplat Grassland Institute and Unpublished graphics from membership presentation April 1992.

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VEGETATION

The vegetation of the Klaserie Private Nature Reserve has been described previously by Schneebeli (1983), Witkowski (1983), Scholes (1987), Kruger (1988), and mapped by Zambatis (1983) (Figure 6). Under the system of landscape units developed in the Kruger National Park by Gertenbach (1983) the vegetation and soil complexes found in the Klaserie Private Nature Reserve area are mixed Combretum/Terminalia Woodland in the South with Olifants River Rugged Veld in the north. Woodland dominated by Combretum/Colophospermum occur in the east. Although the previously cited vegetative descriptions do differ slightly, and are based solely on plant associations, these broader classifications are sufficiently similar for comparative purposes (Scholes 1987).

At the broader level the vegetation of the Klaserie Private Nature Reserve falls into the Tropical Bush and Savanna Type III as described by Acocks (1988). It is more closely defined as Veld Type 11, Arid Lowveld. As noted, Colophospermum mopane dominates in the northeast. Otherwise Acacia nigrescens, Combretum apiculatum and Sclerocarya birrea are the dominant trees.

Riparian areas are floristically more diverse than the habitats in which they occur (Olbrich 1984). These riparian areas

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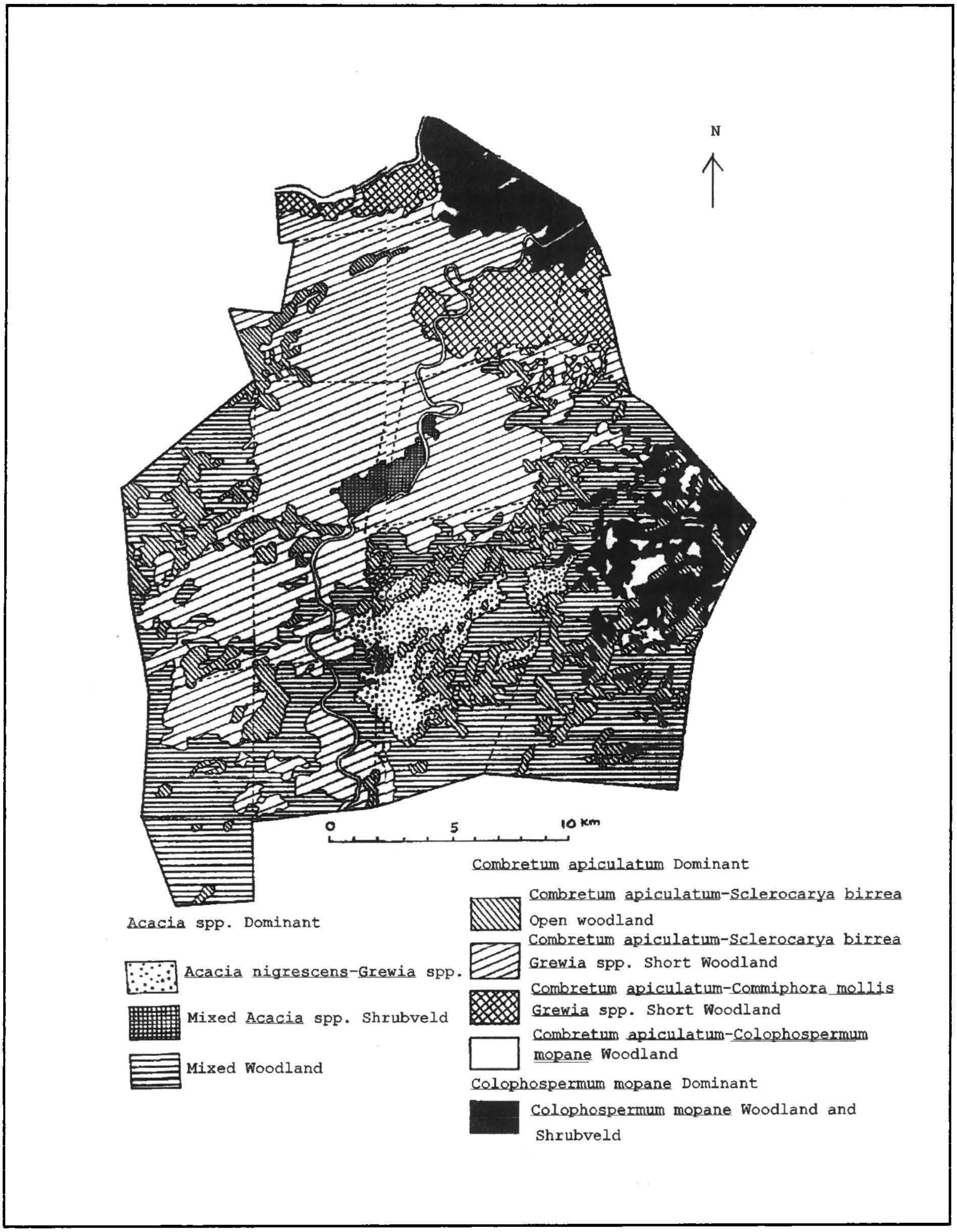

Figure 6: The major vegetation associations of the Klaserie Private Nature Reserve, based on Zambatis (1983)

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generally exhibit opportunistic intrusions of tree species other than the dominants previously listed. Most common riparian dominant trees Spirostachys africana, Schotia brachypetala, Combretum imberbe and Lonchocarpus capassa.

Key grass species which are most commonly encountered on the Klaserie Private Nature Reserve include: Aristida congesta, Bothriochloa radicans, Eragrostis rigidior, Panicum maximum, Schmidtia pappophoroides and Urochloa mosambicencis. According to Trollope, Potgieter, and Zambatis (1989) these and other key species can be used to assess veld condition accurately in areas of the Kruger National Park adjacent to the Reserve (Appendix A). This aspect is completely discussed in Chapter 3.

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CHAPTER THREE: HABITATS

INTRODUCTION

Herbivore habitats within the Klaserie Private Nature Reserve comprise the sum of its enclosed vegetative and topographical features, less the administrative centre and various fenced camps. The use by a given species of such features is, by definition, its habitat (Odum 1971). A species' habitat may be defined by the physical characteristics of the area it inhabits in tandem with environmental influences (Stoddart Smith & Box 1975). However, the basis of such definition with herbivores is primarily vegetative. Herbivore affinity for certain habitats due to specific floristic components is well documented (Leuthold and Leuthold 1972, Hirst 1975, Owaga 1975, Johnson 1980).

The use of different areas or area components by a herbivore species within the spatial and temporal parameters of a fixed or overlapping habitat niche, is referred to as ecological separation (Eltringham 1979). Such separation is the result of each species' differing needs, preferences and abilities within the context of the available habitats. In the case of the Klaserie Private Nature Reserve, and most fenced reserves, the enclosed habitats are being modified constantly by both human activity and herbivore utilisation. It is, therefore, necessary also to monitor constantly and to redefine each species' habitat

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to prevent over utilisation, or saturation, of the habitat with subsequent detrimental impacts on the vegetative components (Owen-Smith and Cooper 1987a, Bothma 1989).

Vegetation associations as suggested by Zambatis (1983) classification (Figure 6) have been the core of most subsequent research on the Klaserie Private Nature Reserve (Chapter 2). The more exhaustive studies by Scholes (1987),the former Transvaal Chief Directorate of Nature and Environmental Conservation (De Villiers, pers. comm. *) and the Agricultural Research Council (Peel, pers. comm. **) have all been based on minor modifications of these plant associations.

It has been said that the sole purpose of vegetation classification is to create order through which management may be enhanced (Theron, Bredenkamp & Van Rooyen 1990). Order may be extrapolated as habitat conclusions from the body of vegetative work which has been accomplished on the Klaserie Private Nature Reserve to date.

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Since one purpose of this study is to define the use of specific habitat components; it was reasonable to use those classifications which have already been proven here, rather than to embark on further comprehensive studies along these lines (De Vos and Mosby 1971, Barnes 1976).

METHODS

Zambatis (1983) delimits three broad vegetation associations for the Klaserie Private Nature Reserve, i.e: Acacia species dominant, Combretum apiculatum dominant, and Colophospermum mopane dominant. These have been refined further to eight sub-associations (Figure 6). These sub-associations form the basis of most wildlife management decisions on the Klaserie Private Nature Reserve today. When topographical considerations are superimposed on Figure 6, they suggest 14 distinct habitat types, here numbered 1 to 10, , 11b, 12 and 13 (Figure 7). Type definitions are displayed in Table 1 These types were used as the basis of the field investigations reported on here and provide a convenient cross-reference to other work which has been done previously. This method allowed site specific data collection and monitoring ability (Collinson 1985).

Within this framework, easily replicated survey routes were established in each of the 14 indicated habitat types (Figure 8 & Table 1). Route, or transect, length varied from 8,0 to 40,5

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Table 1: Klaserie Private Nature Reserve habitat types with numerical equivalents as displayed in Figure 7, after Zambatis (1983).

HABITAT TYPE	DESCRIPTION
1	Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland-Oliphants River Periphery.
2	Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Western Extension.
3	Colophospermum mopane Woodland and shrubveld-Oliphants River Periphery.
4	Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland with Sclerocarya birrea Intrusions.
5	Central Mixed Woodlands.
6	Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Eastern Extension.
7	Colophospermum mopane Dominant Mixed Woodland and Shrubveld with Combretum apiculatum Intrusions.
8	Western Mixed Woodlands
9	Mixed Acacia spp. Shrubveld-Klaserie River Corridor
10	Acacia nigrescens-Grewia spp. Woodlands.
11a	South Western Mixed Woodlands.
11b	South Eastern Mixed Woodlands.
12	Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodlands with Open Woodland Intrusions.
13	Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Southern Extension.

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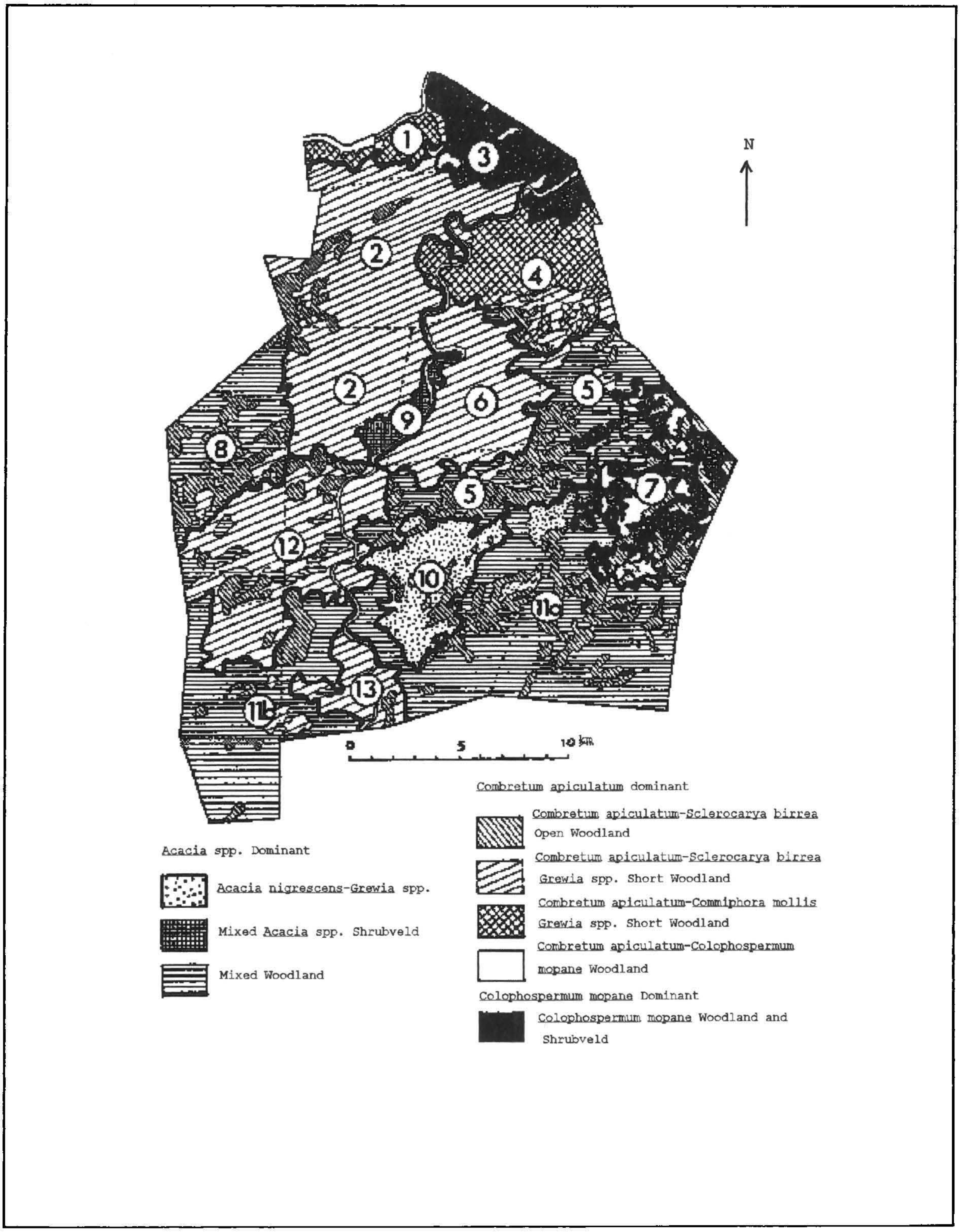

Figure 7: Vegetation map used in Klaserie Private Nature Reserve management, after Zambatis (1983). Habitat types used (Table 1) are numbered 1-13.

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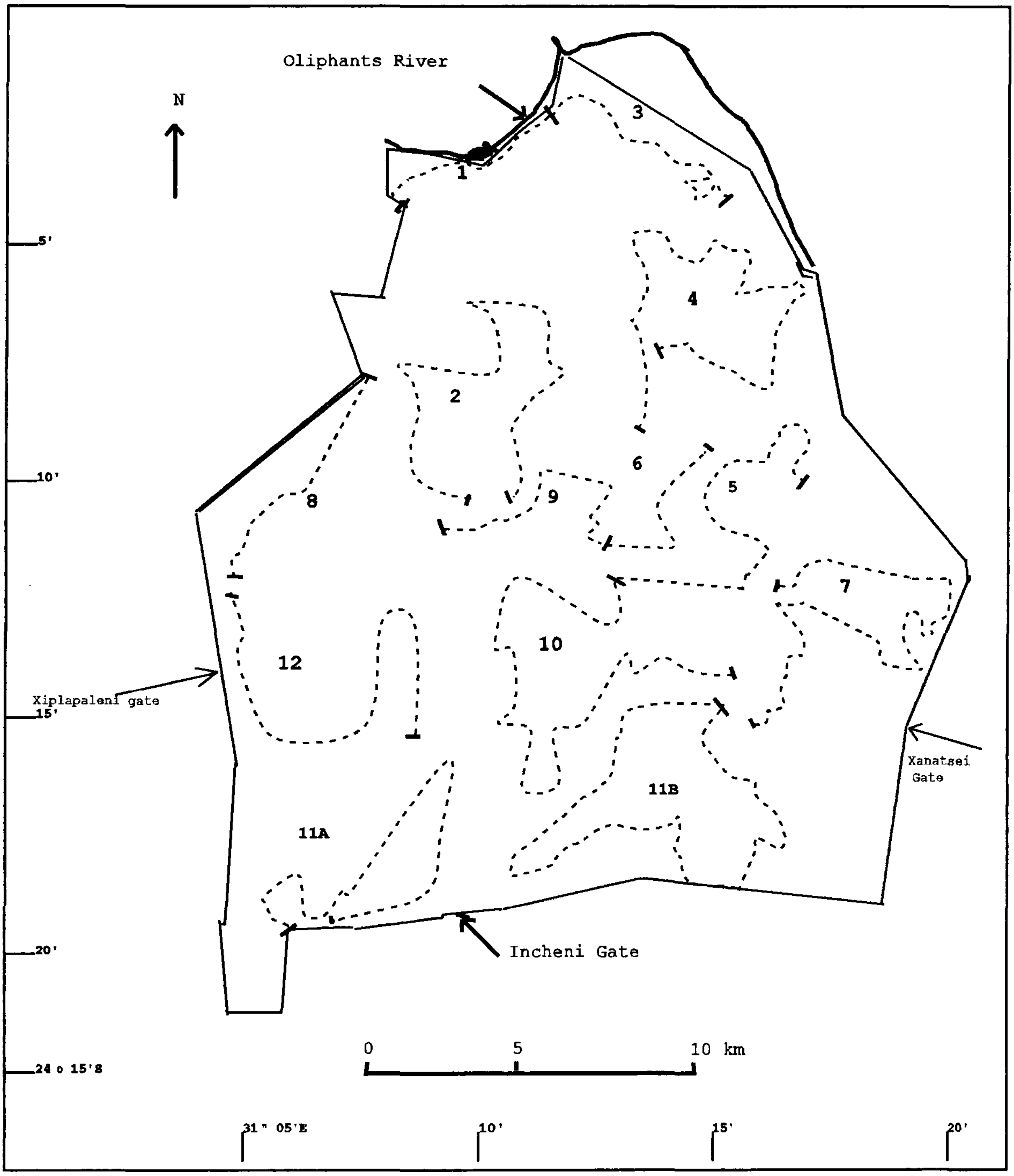

Figure 8: Study area with survey routes used in data collection 1990-1992, Klaserie Private Nature Reserve

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km and totalled 326 km. (Table 2). The length of each transect was proportional to the size of each habitat type area and was designed so as to include a representative sample which could be accomplished within optimum observation hours (Hirst 1969, Bransbt and Tainton 1977, Burnham et al. 1980, Wentzel 1989).

Due to the size of the area being surveyed and the sampling route lengths required, it was necessary to install transects along existing roads and tracks. The graded surfaces and bush tracks on the Klaserie Private Nature Reserve are estimated to total approximately 2 000 km (Leibnitz, pers. comm.*). This is up from estimates by Zambatis (1982) of 1 400 km. Thus adequate selection possibilities were available for representative transects to be installed, in each habitat type, with a minimum of observer bias (Burnham and Anderson 1984, Schutte 1986).

To make the vegetation data as reliable as possible, it was not noted if a subject herbivore was observed within 250 m. of a water hole or directly in a graded road. However, in such instances the actual herbivore occurrence was noted for other

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Table 2: Schedule of transect routes used in the habitat surveys by route number and habitat type, day surveyed and length of route, Klaserie Private Nature Reserve, Northern Transvaal lowveld, South Africa, as used in herbivore and habitat data collection routines from 1990 to 1992.

ROUTE NUMBER	DAY OF CYCLE SURVEYED	DISTANCE
10	1	26,0
6	2	21,0
9	2	8,0
8	3	11,0
12	3	25,0
2	4	32,5
7	5	40,0
4	6	33,0
11a	7	40,5
5	8	35,0
11b	9	18,0
13	9	9,5
1	10	11,0
3	10	15,5
TOTAL		326,0

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uses. This decision was taken because of the disruption of vegetation caused by mechanical removal along roads or by concentrated utilisation and trampling around watering points (Thrash 1993). It was assumed that such animals were present there because of the water, or disturbed vegetation and not because of real habitat-related vegetation characteristics (Zambatis 1982). Other pertinent environmental factors which might determine distribution of game or their utilisation of vegetation were also recorded (Chapter 4) (Coetzee 1980).

Qualitative vegetation data were collected at each point where a given herbivore was observed (Table 3). This was done to isolate herbivore-specific habitat elements used to assist in the determination of habitat preferences. Due to the generally heavy bush present on the Klaserie Private Nature Reserve, it was further decided that no plot would be located more than 250 m on either side of the transect. This allowed for maximum visibility situations in most habitat types, and provided a 500 m transect width. The plot centre for each observation was the location physically occupied by one of the subject herbivores (Table 3) at the moment when it was first sighted, as determined by visual approximation and confirmed by spoor.

In the case of multiple individuals or herd observations, the plot centre was located at the approximate centre of the herd location at the moment of actual sighting. From the subsequent

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Table 3: Vegetation data description, as gathered during 1990-1992, Klaserie Private Nature Reserve in the Northern Transvaal lowveld, for herbivore habitat relations study.

INDEX	DESCRIPTION
OPEN AREA	Sighting in an open area of at least 50 x 50 m With substantially reduced browse stem densities? Y/N
VISIBILITY DISTANCE TOTAL	Total visibility in metres at observation point
VISIBILITY DISTANCE TO ANIMAL	Visibility in metres to observed animal(s)
VISIBILITY DISTANCE AT ANIMAL	Visibility from animals perspective
UTILISATION OF BROWSE	Utilisation of observation area expressed as a percentage
UTILISATION OF GRASS	where 1=light utilisation (0-30%), 2= moderate utilisation (31-60%), 3= heavy utilisation (61-80%)and 4= excessive utilisation (>80%) of annual available production.
PHENOLOGY OF GRASS	Observed grass 1=Shoot 2=Bud/Boot 3=Seedhead 4=Cured
PHENOLOGY OF BROWSE	Observed shrub 1=Bud/Bloom 2=Young leaf 3=Mature Leaf 4=Dormant
GRASS/FORB	Ratio of grasses/forbs at observation centre in 1 m^2 plot
BARE GROUND	Percentage of bare ground observation centre in 1 m^2 plot
DOMINANT GRASS	Four letter Species identification for visually dominant grass in 10 x 10 plot

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Table 3: Continued

SUB-DOMINANT GRASS	Four letter Species identification for visually sub-dominant grass in 10 x 10 m plot
DOMINANT WOODY	Four letter Species identification for visually dominant in vicinity
SUB-DOMINANT WOODY	Four letter Species identification for visually sub-dominate in vicinity.
ELEPHANT DAMAGE	Tree mortality induced by elephants (trees = greater than 85 mm as measured diameter at breast height) within 20 m radius of plot centre, expressed as the number of dead trees./ N=new O=old where new damage is less than or equal to 6 months, and old damage is greater than six months
DAMAGED SPECIES	Predominate species on which mortality is occurring.
GRASS HEIGHT	Height of available grasses in cm at observation point by disc pasture meter.
GRASS HEIGHT NORTH	As above 5 m North
GRASS HEIGHT WEST	As above 5 m West
GRASS HEIGHT SOUTH	As above 5 m South
GRASS HEIGHT EAST	As above 5 m East
CROWN COVER	Crown cover as a percentage at m^2 observation plot
CROWN COVER NORTH	Crown cover as a percentage at m^2 plot 5 m North
CROWN COVER WEST	Crown cover as a percentage at m^2 plot 5 m West
CROWN COVER SOUTH	Crown cover as a percentage at m^2 plot 5 m South
CROWN COVER EAST	Crown cover as a percentage at m^2 plot 5 m East
BROWSE HEIGHT	Average height of browse in metres at observation site. Calculated by "Nearest Neighbour" method at five points as per Crown Cover readings

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plot centre a square-metre plot was constructed from two folding carpenter's rules, two sticks of 2 m, and laid out according to a compass reading along an axis based on true North (Figure 9). The purpose of this procedure was to eliminate observer bias in plot and sub-plot location (United States Department of Agriculture, Forest Service 1973). Four sub-plots were then installed on the 90° compass bearings with each sub-plot's centre being 5 m from the centre of the main plot. This was done to provide the basis for an unbiased, mean figure for disc pasture meter readings, crown cover percentages, and to avoid the effect of "chaining", or clustering, in nearest neighbour browse height observations (Pielou 1984, Burnham et al. 1985).

To reflect the realities of the phenological cycle of the plants under consideration (Merrill 1978), all data were subsequently divided according to season; dry or wet according to the rainfall patterns on the Klaserie Private Nature Reserve (Chapter 2) (Inglis 1976). Dry season data were defined as that collected on 1 May to 30 September. Wet season data were collected on 1 October to 30 April (Gertenbach 1980). The variables were collected at each herbivore sighting and entered with the number of the herbivore(s) observed (Table 4), variables specific to qualitative vegetation data (Table 3) were:

Open Area: Variable 26.

Utilisation of Grasses: Variable 30.

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Utilisation of Browse: Variable 31.

Phenology of Grass: Variable 32.

Phenology of Browse: Variable 33.

Grass/Forb Ratio: Variable 34.

Bare Ground: Variable 35.

Dominant Grass: Variable 36.

Sub-Dominant Grass: Variable 37.

Dominant Woody: Variable 38.

Sub-Dominant Woody: Variable 39.

Old Elephant Damage: Variable 41.

New Elephant Damage: Variable 42.

Damaged Species: Variable 43.

Grass Height: Variables 44-48.

Crown Cover: Variables 49-53.

Browse Height: Variable 54.

Variables 1-25 and 27-29 are described in Chapter 4 and are non-vegetation variables.

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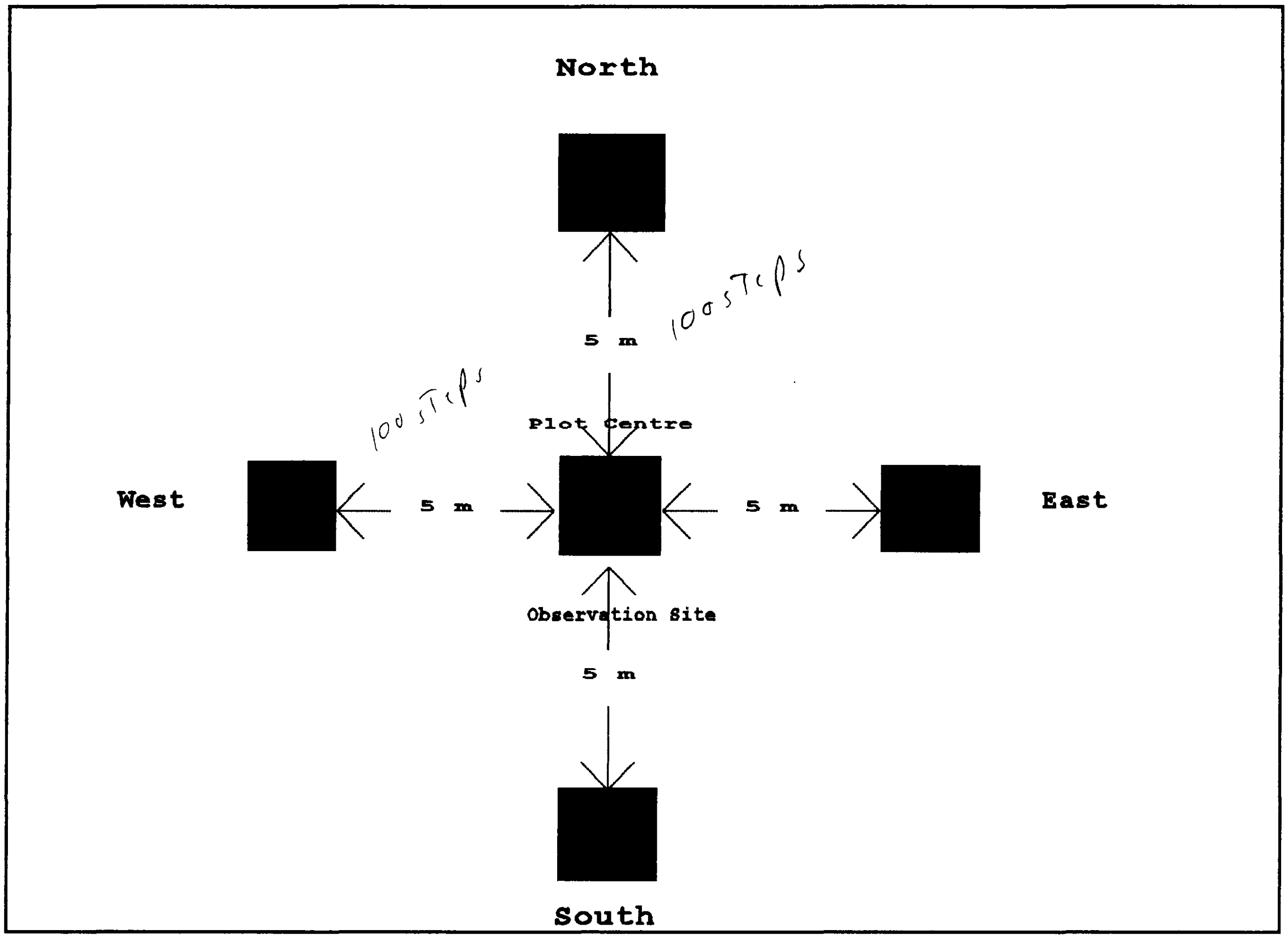

Figure 9: Detail of data collection plot design used to gather vegetation data in each habitat type from 1990-1992, Klaserie Private Nature Reserve.

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Table 4: Herbivores studied with assigned numerical key indicating species number in study references, Klaserie Private Nature Reserve.

SPECIES	ENGLISH NAME	AFRIKAANS NAME	NUMBER
Aepyceros melampus	Impala	Rooibok	1
Equus burchelli	Burchell's zebra	Bontkwagga	2
Connochaetes taurinus	Blue wildebeest	Blouwildebees	3
Syncerus caffer	Cape buffalo	Buffel	4
Loxodonta africana	Elephant	Olifant	5
Tragelaphus strepsiceros	Kudu	Koedoe	6
Cerathotherium simum	White rhinoceros	Witrenoster	7
Giraffa camelopardalis	Giraffe	Kameelperd	8
Phacochoerus aethiopicus	Warthog	Vlakvark	9

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RESULTS

Data collected in the present study indicates problems in the southern grazing habitat types (Figures 10-15 and Table 5). Disc Pasture meter readings taken at all plots and displayed as wet and dry season means show the lowest readings in these southern grazing types, but particularly in types 10 (Acacia nigrescens-Grewia spp.) and 11a (South Western Mixed Woodlands). Grazing pressure appears to be either unequally skewed towards these portions of the reserve, or it is having a more pronounced vegetative effect in these habitat types.

This effect is further illustrated (Figure 12) by isolating the dry season utilisation of grasses by herbivores in all Klaserie Private Nature Reserve habitat types. Once again, heaviest grazing is generally confined to the southern habitat types, but to 10 (Acacia nigrescens-Grewia spp. and 11a (South Western Mixed Woodlands) in particular. High utilisation categories in type 1 (Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland-Oliphants River periphery) are likely due to its riparian dominated location and the subsequent dry season concentrations of herbivores there (Schneebeli 1983). Browse utilisation by habitat type is illustrated in Figure 14 and is cumulative for wet and dry seasons. The total numbers of observations may also have affected some of the data in some of the types as is illustrated by Figure 15. Dry season data on grass/forb ratios (Figure 13) should also be indicative of the most severely impacted areas as this is the period of greatest stress on

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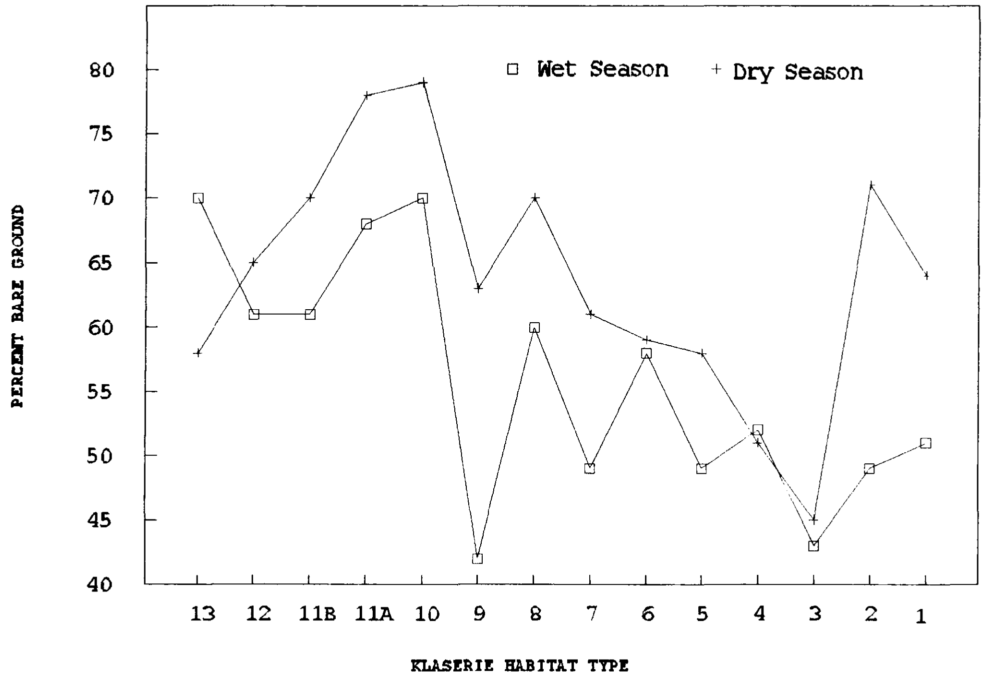

Figure 10: Percentage bare ground by habitat type and season in areas selected by herbivore in the , Klaserie Private Nature Reserve, Northern Transvaal, from 1990-1992 to show grazing impacts.

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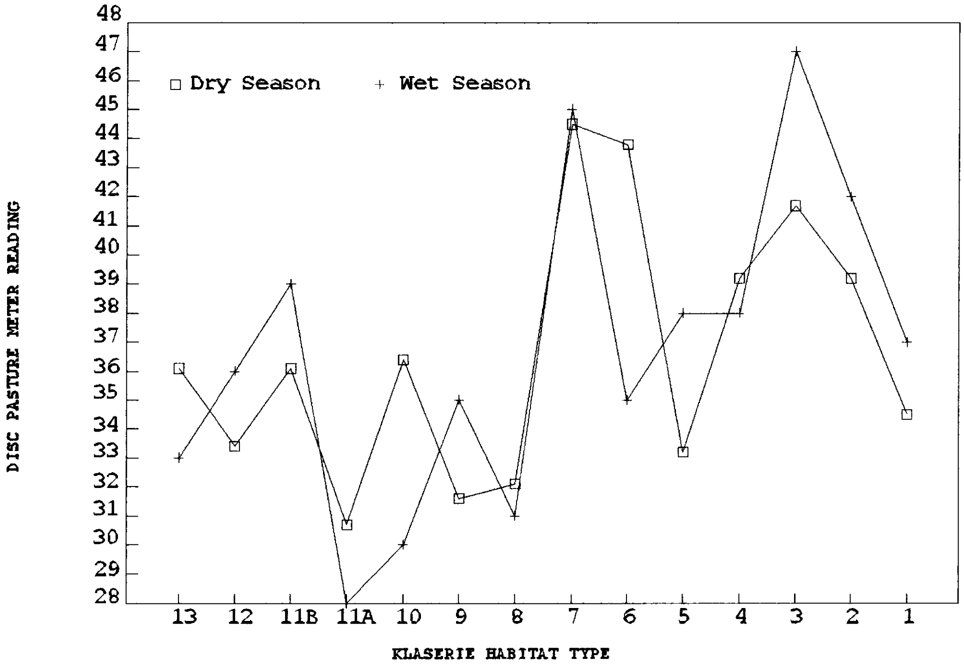

Figure 11: Mean Disc pasture meter readings (Cm) by season in the Klaserie Private Nature Reserve habitat types, from 1990-1992, to show relative grass availability. Readings are in millimetres.

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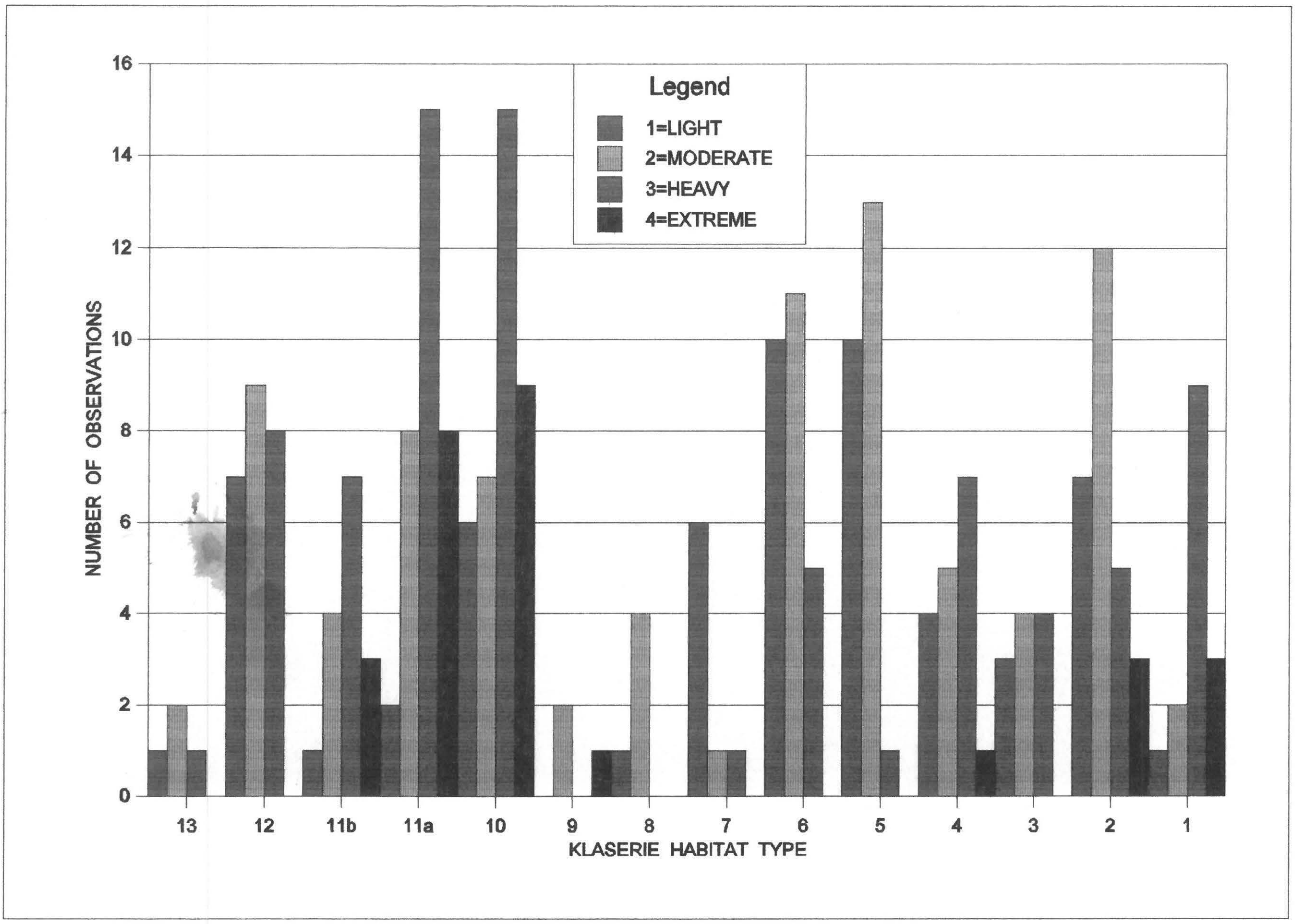

Figure 12: Dry season utilisation scores of grasses by Klaserie Private Nature Reserve Habitat Type, where 1=light utilisation (0-30%), 2=moderate utilisation (31-60%), 3=heavy utilisation (61-80%) and 4=excessive utilisation (>80%) of annual available production. Data collected 1990 to 1992, Showing grazing utilisation by habitat type.

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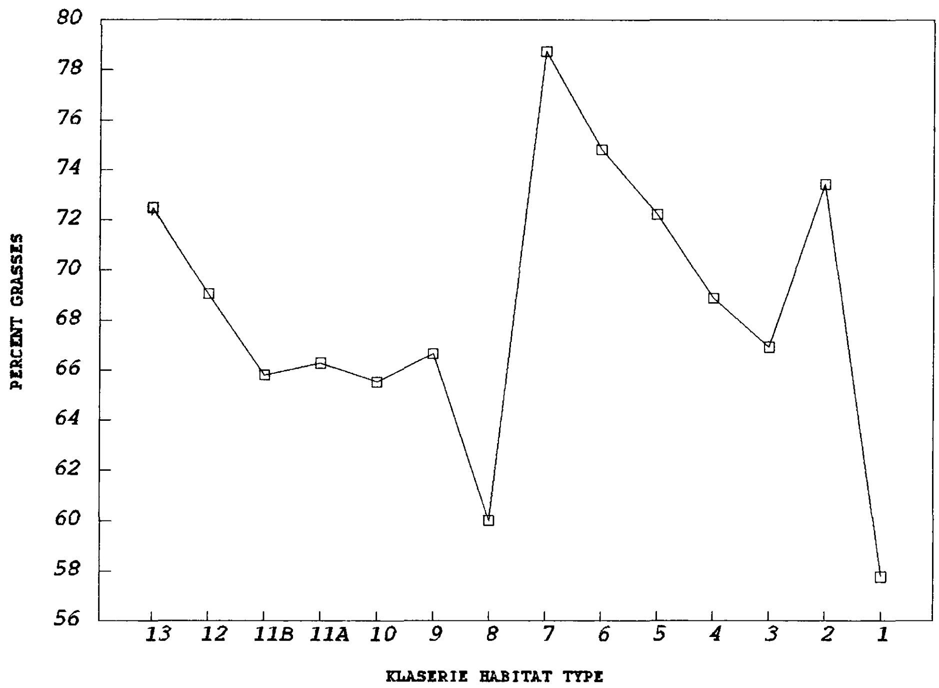

Figure 13: Percentage of grasses relative to forbs by square metre, by Klaserie Private Nature Reserve habitat type. Data collected from 1990 to 1992 showing relative grazing component availability.

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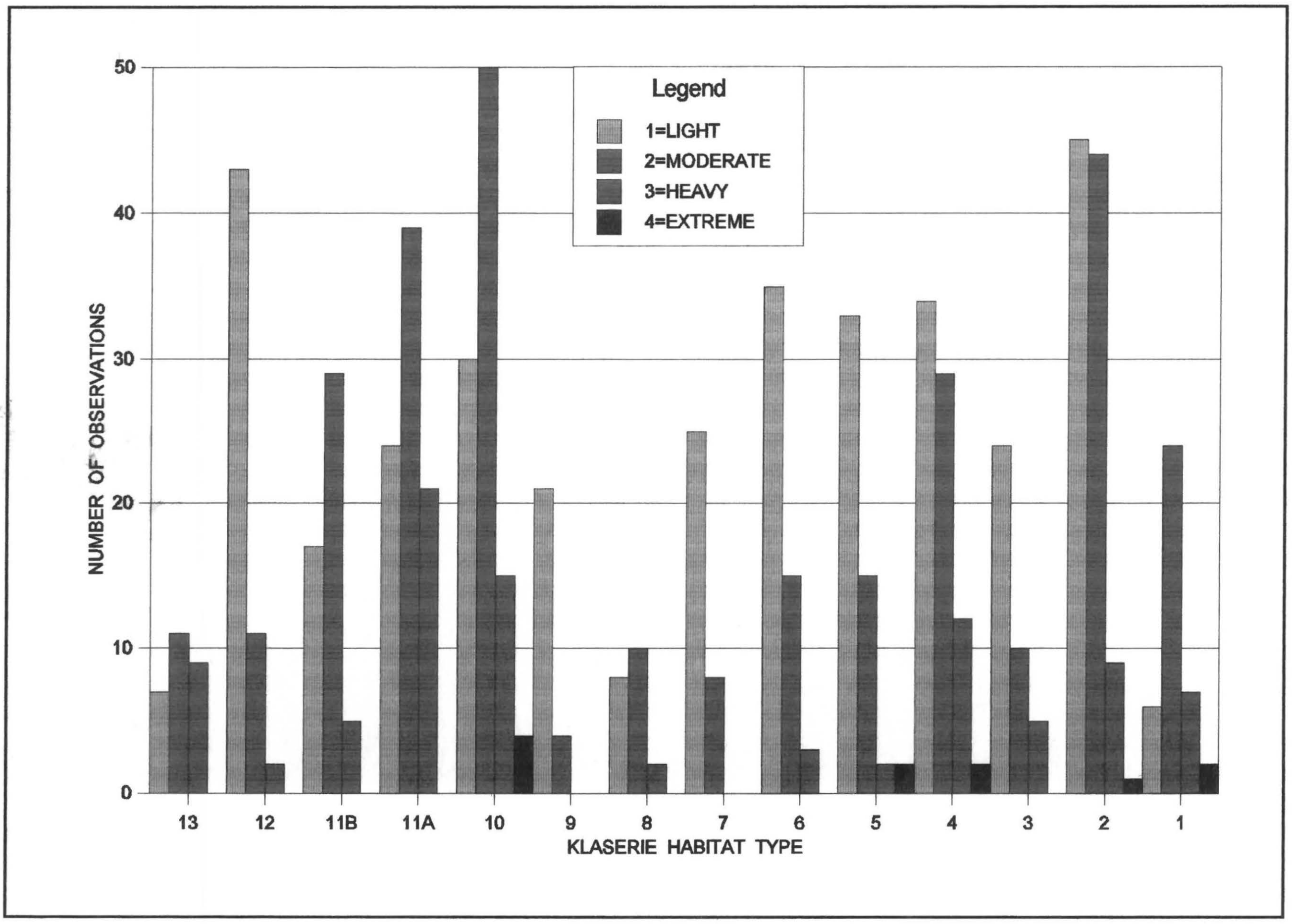

Figure 14: Browse utilisation by herbivores in the Klaserie Private Nature Reserve by Habitat Type, where 1= light utilisation (0-30%), 2=moderate utilisation (31-60%), 3=heavy utilisation (61-80%) and 4=excessive utilisation (>80%) of available growth. Data collected 1990 to 1992, showing utilisation by habitat type cumulative for wet and dry seasons.

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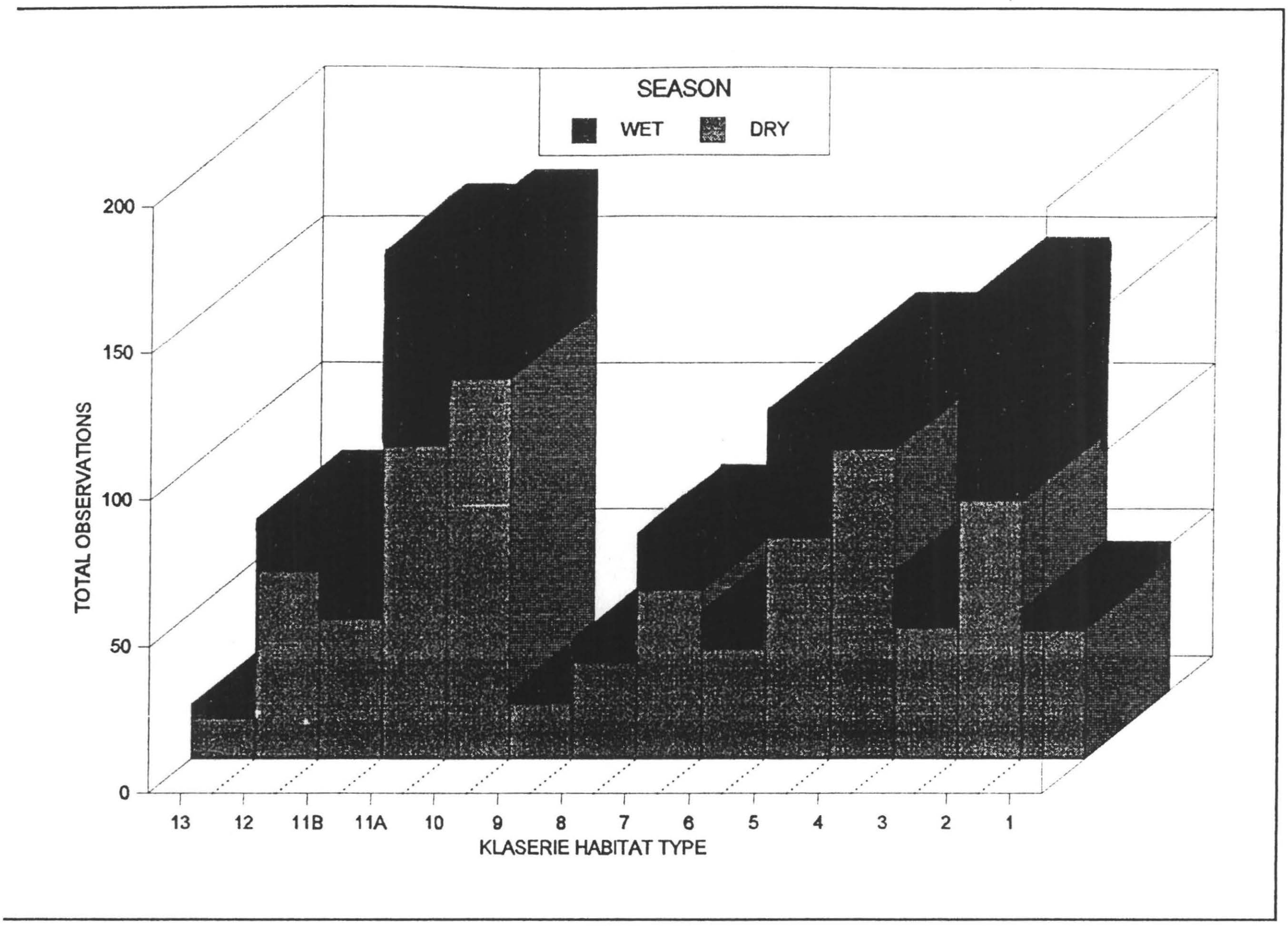

'igure 15: Total number of observations (samples) taken 1990-1992 in the Klaserie Private Nature Reserve, Northern Transvaal. Showing herbivores observed by habitat type and season. Sample taken where one or more animals are present.

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Table 5: Summary of data collected from 1990-1992 on the Klaserie Private Nature Reserve as displayed in Figures 10-16.

SEASON	HABITAT TYPE	SAMPLES	MEASURE	MEAN	DISPLAY FIGURE
Dry	1	44	Percent	64,0	Figure 10
Dry	2	88	Percent	70,0	Figure 10
Dry	3	45	Percent	44,5	Figure 10
Dry	4	106	Percent	50,5	Figure 10
Dry	5	76	Percent	57,0	Figure 10
Dry	6	38	Percent	59,0	Figure 10
Dry	7	58	Percent	60,5	Figure 10
Dry	8	33	Percent	69,5	Figure 10
Dry	9	19	Percent	63,5	Figure 10
Dry	10	130	Percent	78,5	Figure 10
Dry	11a	107	Percent	77,0	Figure 10
Dry	11b	48	Percent	70,0	Figure 10
Dry	12	64	Percent	65,0	Figure 10
Dry	13	14	Percent	57,5	Figure 10
Wet	1	7	Percent	51,5	Figure 10
Wet	2	67	Percent	49,0	Figure 10
Wet	3	19	Percent	43,0	Figure 10
Wet	4	30	Percent	51,0	Figure 10
Wet	5	43	Percent	49,0	Figure 10
Wet	6	12	Percent	58,5	Figure 10
Wet	7	19	Percent	49,0	Figure 10
Wet	8	8	Percent	60,0	Figure 10
Wet	9	4	Percent	42,0	Figure 10
Wet	10	48	Percent	70,5	Figure 10
Wet	11a	66	Percent	63,5	Figure 10
Wet	11b	20	Percent	61,0	Figure 10
Wet	12	18	Percent	61,0	Figure 10
Wet	13	5	Percent	70,0	Figure 10

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Table 5: Continued

Dry	1	44	Millimetres	34,25	Figure 11
Dry	2	88	Millimetres	39.25	Figure 11
Dry	3	45	Millimetres	41,50	Figure 11
Dry	4	106	Millimetres	39,25	Figure 11
Dry	5	76	Millimetres	33,00	Figure 11
Dry	6	38	Millimetres	44,00	Figure 11
Dry	7	58	Millimetres	44,50	Figure 11
Dry	8	33	Millimetres	32,00	Figure 11
Dry	9	19	Millimetres	31,50	Figure 11
Dry	10	130	Millimetres	36,50	Figure 11
Dry	11a	107	Millimetres	30,50	Figure 11
Dry	11b	48	Millimetres	36,00	Figure 11
Dry	12	64	Millimetres	33,50	Figure 11
Dry	13	14	Millimetres	36,25	Figure 11
Wet	1	7	Millimetres	37,25	Figure 11
Wet	2	67	Millimetres	42,00	Figure 11
Wet	3	19	Millimetres	47,25	Figure 11
Wet	4	30	Millimetres	37,75	Figure 11
Wet	5	43	Millimetres	37,75	Figure 11
Wet	6	12	Millimetres	34,74	Figure 11
Wet	7	19	Millimetres	45,00	Figure 11
Wet	8	8	Millimetres	31,00	Figure 11
Wet	9	4	Millimetres	35,00	Figure 11
Wet	10	48	Millimetres	30,00	Figure 11
Wet	11a	66	Millimetres	28,00	Figure 11
Wet	11b	20	Millimetres	39,00	Figure 11
Wet	12	18	Millimetres	36,00	Figure 11
Wet	13	5	Millimetres	33,25	Figure 11
Dry	1	44	Utilisation	2,650	Figure 12
Dry	2	88	Utilisation	1,925	Figure 12
Dry	3	45	Utilisation	1,675	Figure 12

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Table 5: Continued

Dry	4	106	Utilisation	2,200	Figure 12
Dry	5	76	Utilisation	1,550	Figure 12
Dry	6	38	Utilisation	1,800	Figure 12
Dry	7	58	Utilisation	1,675	Figure 12
Dry	8	33	Utilisation	1,800	Figure 12
Dry	9	19	Utilisation	2,675	Figure 12
Dry	10	130	Utilisation	2,700	Figure 12
Dry	11a	107	Utilisation	2,675	Figure 12
Dry	11b	48	Utilisation	2,300	Figure 12
Dry	12	64	Utilisation	1,575	Figure 12
Dry	13	14	Utilisation	2,500	Figure 12
Both	1	51	Percent	57	Figure 13
Both	2	155	Percent	73	Figure 13
Both	3	63	Percent	67	Figure 13
Both	4	136	Percent	69	Figure 13
Both	5	119	Percent	72	Figure 13
Both	6	50	Percent	75	Figure 13
Both	7	77	Percent	79	Figure 13
Both	8	41	Percent	60	Figure 13
Both	9	23	Percent	67	Figure 13
Both	10	178	Percent	65	Figure 13
Both	11a	173	Percent	66	Figure 13
Both	11b	68	Percent	65	Figure 13
Both	12	82	Percent	69	Figure 13
Both	13	19	Percent	72	Figure 13
Dry	1	44	Utilisation	2,115	Figure 14
Dry	2	88	Utilisation	1,660	Figure 14
Dry	3	45	Utilisation	1,380	Figure 14
Dry	4	106	Utilisation	1,590	Figure 14
Dry	5	76	Utilisation	1,440	Figure 14
Dry	6	38	Utilisation	1,225	Figure 14

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Table 5: Continued

Dry	7	58	Utilisation	1,500	Figure 14
Dry	8	33	Utilisation	1,400	Figure 14
Dry	9	19	Utilisation	2,000	Figure 14
Dry	10	130	Utilisation	2,130	Figure 14
Dry	11a	107	Utilisation	2,165	Figure 14
Dry	11b	48	Utilisation	1,580	Figure 14
Dry	12	64	Utilisation	1,380	Figure 14
Dry	13	14	Utilisation	2,255	Figure 14
Wet	1	7	Utilisation	2,110	Figure 14
Wet	2	67	Utilisation	1,585	Figure 14
Wet	3	19	Utilisation	1,525	Figure 14
Wet	4	30	Utilisation	1,860	Figure 14
Wet	5	43	Utilisation	1,290	Figure 14
Wet	6	12	Utilisation	1,520	Figure 14
Wet	7	19	Utilisation	1,120	Figure 14
Wet	8	8	Utilisation	1,800	Figure 14
Wet	9	4	Utilisation	1,100	Figure 14
Wet	10	48	Utilisation	1,730	Figure 14
Wet	11a	66	Utilisation	2,160	Figure 14
Wet	11b	20	Utilisation	1,885	Figure 14
Wet	12	18	Utilisation	1,230	Figure 14
Wet	13	5	Utilisation	1,955	Figure 14
Dry	1	44	Samples	44	Figure 15
Dry	2	88	Samples	88	Figure 15
Dry	3	45	Samples	45	Figure 15
Dry	4	106	Samples	106	Figure 15
Dry	5	76	Samples	76	Figure 15
Dry	6	38	Samples	38	Figure 15
Dry	7	58	Samples	58	Figure 15
Dry	8	33	Samples	33	Figure 15
Dry	9	19	Samples	19	Figure 15

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Table 5: Continued

Dry	10	130	Samples	130	Figure 15
Dry	11a	107	Samples	107	Figure 15
Dry	11b	48	Samples	48	Figure 15
Dry	12	64	Samples	64	Figure 15
Dry	13	14	Samples	14	Figure 15
Wet	1	7	Samples	7	Figure 15
Wet	2	67	Samples	67	Figure 15
Wet	3	19	Samples	19	Figure 15
Wet	4	30	Samples	30	Figure 15
Wet	5	43	Samples	43	Figure 15
Wet	6	12	Samples	12	Figure 15
Wet	7	19	Samples	19	Figure 15
Wet	8	8	Samples	8	Figure 15
Wet	9	4	Samples	4	Figure 15
Wet	10	48	Samples	48	Figure 15
Wet	11a	66	Samples	66	Figure 15
Wet	11b	20	Samples	20	Figure 15
Wet	12	18	Samples	18	Figure 15
Wet	13	5	Samples	5	Figure 15
Both	1	51	Animals	306	Figure 16
Both	2	155	Animals	2125	Figure 16
Both	3	63	Animals	642	Figure 16
Both	4	136	Animals	1677	Figure 16
Both	5	119	Animals	738	Figure 16
Both	6	50	Animals	1103	Figure 16
Both	7	77	Animals	1147	Figure 16
Both	8	41	Animals	299	Figure 16
Both	9	23	Animals	642	Figure 16
Both	10	178	Animals	1527	Figure 16
Both	11a	173	Animals	1587	Figure 16
Both	11b	68	Animals	570	Figure 16

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Table 5: Continued

Both	12	82	Animals	382	Figure 16
Both	13	19	Animals	146	Figure 16

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herbivores in the reserve. In this scenario, habitat types 10 (Acacia nigrescens-Grewia spp.), 11a (South Western Mixed Woodlands) and 11b (South Eastern Mixed Woodlands) again emerge in a relatively uniform category reflecting a poor grass component. Type 1 (Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland-Oliphants River periphery) and 9 (Mixed Acacia spp. Shrubveld-Klaserie River Corridor), again reflect dry season concentrations while data from habitat type 8 (Western Mixed Woodlands) show another emerging problem area previously indicated in the analysis of Figure 11. When total herbivore sightings are considered (Figure 15) a similar pattern emerges. Highest overall sightings in the study accumulated in types 10 (Acacia nigrescens-Grewia spp.) and 11a (South Western Mixed Woodlands), particularly so in the dry season. This adds further evidence to skewed impacts in these types. However, total herbivore observations also reflect high numbers of observations in types 2 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Western Extension) and 4 (Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland with Sclerocarya birrea intrusions), particularly in the dry season.

Herbivore impact on the browse component of the Klaserie Private Nature Reserve is less clearly defined. However, some evidence makes it clear that a heavy utilisation of the woody component is also occurring in the southern habitat types, particularly habitat types 10 (Acacia nigrescens-Grewia spp.), 11a (South Western Mixed Woodlands) and 13 (Combretum apiculatum-Sclerocarya birrea, Grewia

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spp. Short Woodland-Southern Extension) (Figure 14). From this data some impact on the riparian habitat types 1 (Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland-Oliphants River periphery) and 9 (Mixed Acacia spp. Shrubveld-Klaserie River Corridor) are also apparent, mirroring the situation illustrated in Figure 11. In the case of habitat type 1 (Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland-Oliphants River periphery) the browsing levels appear to occur equally in both seasons. In habitat type 9 (Mixed Acacia spp. Shrubveld-Klaserie River Corridor), browsing is substantially heavier during the dry months. All other habitat types experience a light level of browse utilisation throughout the year.

Figure 14 also shows that the southern habitat type, 12 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodlands with Open Woodland Intrusion), is noticeably browsed in a very light manner, as are habitat types 5 (Central Mixed Woodlands), 6 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Eastern Extension) and 7 (Colophospermum mopane Dominant Mixed Woodland and Shrubveld with Combretum apiculatum Intrusions). Wet season utilisation of the Colophospermum mopane dominated habitat type 7 (Colophospermum mopane Dominant Mixed Woodland and Shrubveld with Combretum apiculatum Intrusions) is extremely light. This may be explained partially by the dense foliage occurring during the wet season which makes animal sightings difficult to obtain and which limits available data since these are based entirely on such sightings. Such a prevailing situation also limits herbivore

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visibility and causes prey species to be uneasy and, consequently, to shun such areas (Diamond 1986). A similar effect is noticed in the adjacent habitat type 5 (Central Mixed Woodlands), probably for similar reasons. In none of the above cases, as illustrated in Figure 14, can lack of browse be cited as a limiting factor.

Figure 15 indicates potential problems with a scarcity of data in types 9 (Mixed Acacia spp. Shrubveld-Klaserie River Corridor) and 13 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Southern Extension). This is undoubtedly due to the relatively small size of the types relative to others in the reserve and the subsequent short routes in the types (8,0 and 9,5 km respectively). Indeed, Figure 11 is difficult to explain in regard to the latter type excepting for the low number of observations taken in these types (Table 5). Conversely, the apparent seasonal similarity of bare ground in type 4 Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland with Sclerocarya birrea intrusions) must be assumed to be an accurate measure given the high sample size. Figure 15 data for types 10 (Acacia nigrescens-Grewia spp.) and 11a (South Western Mixed Woodlands) adds to the growing body of evidence for the heavy impacts on these types.

Figure 16 illustrates the relative biomass of herbivores observed during the course of the study by habitat type and season. The relatively low habitat impacts displayed for types 2 Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Western

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Extension) and 4 Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland with Sclerocarya birrea intrusions) displayed in Figures 10-14 appears to contrast with the data displayed in Figure 16, However the data are reflective of sightings which are predominately mixed feeders (impala) and browsing species. In contrast types 10 (Acacia nigrescens-Grewia spp.) and 11a (South Western Mixed Woodlands) sightings were comprised predominately of grazing species.

Lastly, it would be wise to include the cumulative observations of the Klaserie Private Nature Reserve habitats and herbivores by long-time land owners on the reserve. These observations, while not completely objective, do have a certain validity by nature of their perspective. Interviews conducted during the course of this study with A.C. Crookes (pers. comm.*), and I.F.G. Gillatt (pers. comm.**), two owners who had the longest personal experience of conditions in the Klaserie Private Nature Reserve, yielded uniform impressions of increasing bush encroachment and elimination of the tall grass component over time. The tall grass component, if it did in fact ever occur in the area, is not present today (data variables 36 and 37).

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**: Mr. I.F.G. Gillatt, P.O. Box 935, Stanger, 4450

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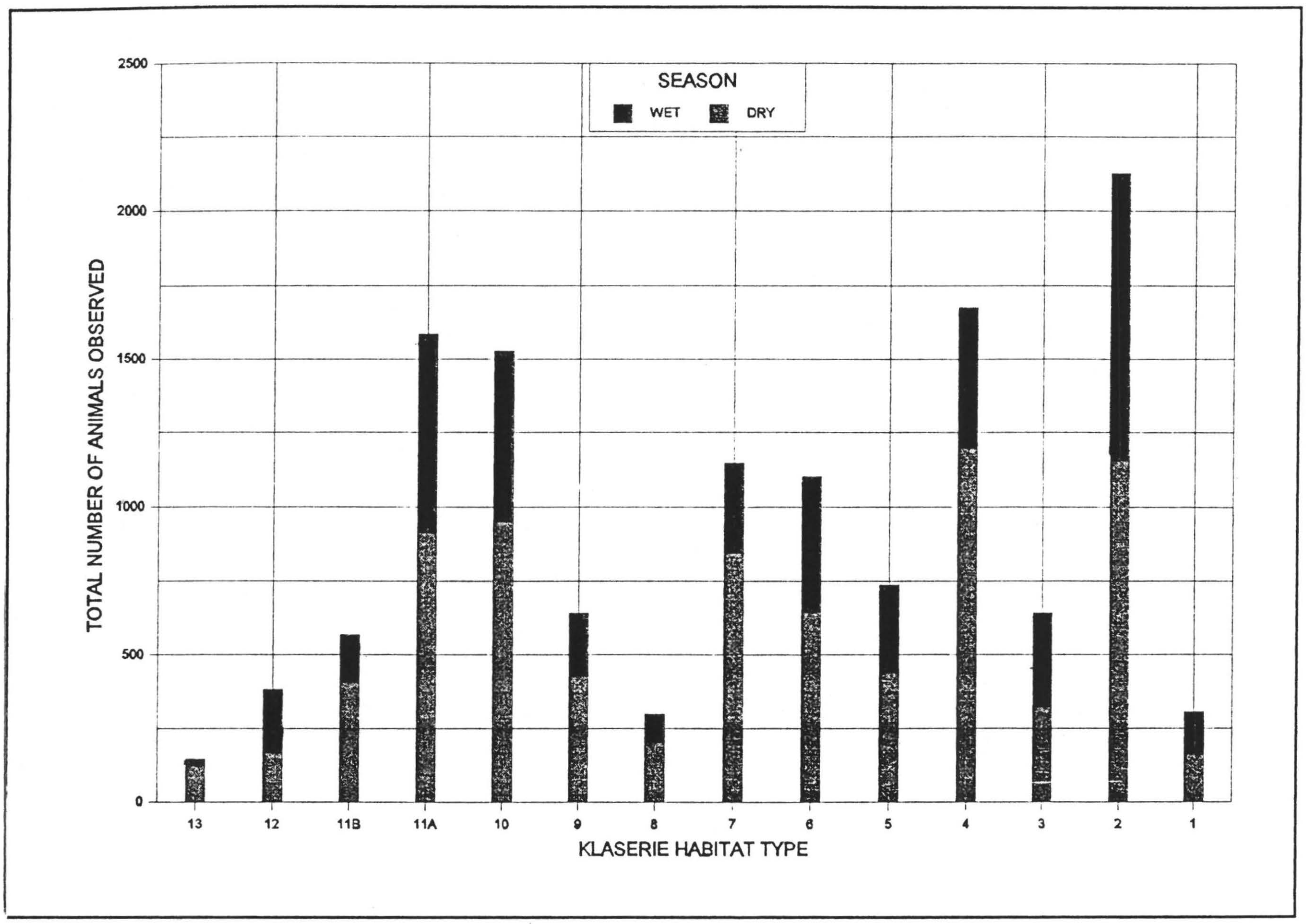

Figure 16: Total animal numbers observed while sampling 1990-1992, Klaserie Private Nature Reserve, Northern Transvaal. Showing relative biomass present by habitat type and season.

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Particularly noteworthy in respect to the implied historical presence of a tall grass component on the Klaserie Private Nature Reserve were the common references by Crookes and Gillatt (op. cit.) to sable antelope as being so common previously (circa 1940's) as to have been utilised for staff rations. This contrasts with the current situation in which staff rations are provided, nearly exclusively, by way of giraffe and impala as the sable antelope population on the Klaserie Private Nature Reserve had reduced to about 8 individuals in 1992.

References to reedbuck and tsessebe were also made as they apparently occurred, in limited numbers, on what is now the Klaserie Private Nature Reserve prior to its inception. Both Crookes and Gillatt (op. cit.)were adamant in their observations that impala were not present in any significant number on what is now the Klaserie Private Nature Reserve, until about the early 1960's.

DISCUSSION

Site-specific studies on the Klaserie Private Nature Reserve by Scholes (1987), Schneebeli (1983), Witkowski (1983) and unpublished data by De Villiers (1989) indicate a potential problem with bush encroachment. Certainly, the study area lies within such parameters, established by Walker (1980) that bush encroachment can be a problem. Scholes' (1987) exhaustive study on bush clearing minimised the broad scale possibility of bush encroachment having occurred on the reserve while emphasising the benefits of bush clearing in known, localised,

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problem areas such as the Colophospermum mopane areas in habitat type 5 (Central Mixed Woodlands).

Schneebeli (1983), compared the habitats of the Klaserie Private Nature Reserve with those of nearby areas of the Kruger National Park. His conclusions showed a high likelihood that bush encroachment was becoming a problem on the Klaserie Private Nature Reserve. Work by Ben-Shahar (1990) in the nearby Sabi-Sand Game Reserve, concluded that bush encroachment was occurring there and was most likely to be found in seepage lines and bottomlands. His data showed that habitats with the greatest likelihood of exhibiting encroachment were those types dominated by Acacia senegal - Acacia tortilis and Acacia nilotica - Euclea divinorum. Such plant species are well represented on the Klaserie Private Nature Reserve, particularly in the southern areas of the reserve.

On the Klaserie Private Nature Reserve areas with these components, specifically Acacia tortilis and Euclea divinorum, exhibited a heavy utilisation of the grazing component according to Witkowski (1983). Research conducted by the Agricultural Research Council during 1991-1992 on both the Sabi-Sand Game Reserve and the Klaserie Private Nature Reserve showed rainfall to be consistently lower on the Klaserie Private Nature Reserve than on the Sabi Sand Private Nature Reserve, while veld types were similar on the two reserves as were mean stocking rates (Peel, pers. comm.*). This would indicate that bush encroachment is at least as likely to be occurring on the

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Klaserie Private Nature Reserve if it is occurring on the Sabi Sand (Walker 1980).

The studies by , Schneebeli (1983), Witkowski (1983),Scholes (1987) and De Villiers 1989), relating to bush encroachment, as well as work by Zambatis (1982, 1983 and 1985) also indicate a potential problem with the overutilisation of the grass/forb component on the Klaserie. The latter problem would, by definition, contribute to the former (Parsons 1991). Soil erosion is identified in all in-depth studies on the Klaserie Private Nature Reserve as a major habitat problem. Indeed, the current and past record of the reserve in systematically planning and accomplishing large and expensive erosion control programmes support the validity of this observation.

Data from De Villiers (1988) are reproduced in Appendix A and is directly applicable by veld type to the present study. Data in Appendix A are corroborated by observations made during this study, while attention is drawn to the work by Trollope et al. (1988) in its interpretation and relevance.

Data gathered between 1990 and 1992 in this study further illustrate the erosion potential under current stocking levels (Figure 10) and are consistent with generally degraded grazing conditions illustrated

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in Appendix A. Conclusions by Zambatis (1985) reflect similar concerns over the slow rate of recovery in cover following the 1983 drought and the generally high levels of poor ground cover. Of greatest concern is the high levels of bare ground found, during both seasons for the period 1990-1992, in types 10 (Acacia nigrescens-Grewia spp.), 11a (South Western Mixed Woodlands), 11b (South Eastern Mixed Woodlands), and 12 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodlands with Open Woodland Intrusion) (Figure 10). This is of concern because these are the most utilised grazing areas on the reserve (Zambatis 1985). Since these areas are the focus of current erosion work, it appears that such a connection may be reasonable. Data from this study points to definite problems in types 10 (Acacia nigrescens-Grewia spp.) and 11a (South Western Mixed Woodlands).

CONCLUSIONS

According to Scholes (1985), bush encroachment is a symptom of an underlying problem, usually a combination of overgrazing, under-browsing and the absence of hot fires. In the case of the Klaserie Private Nature Reserve the above is true, except possibly under-browsing. Recent impacts on the mature over-story tree component by the elephant, first noted by Zambatis (1985), also enter the equation and are discussed further in Chapter 5. The similarities between the Sabi-Sand Game Reserve and the Klaserie Private Nature Reserve and the evidence from Ben-Shahar (1990) that bush encroachment is occurring

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on the Sabi Sand Game Reserve cannot be overlooked in forming a conclusion. It is reasonable that bush encroachment presently is a problem on the Klaserie Private Nature Reserve, at the very least in multiple localised instances.

The exclusion of fire, due to current management practices, dictates that bush encroachment will continue to be present on the Klaserie Private Nature Reserve (Boughey 1963). The enigma of how to overcome insufficient fuel loading as noted in Appendix A, caused by heavy grazing, would seem to be insurmountable under current wildlife management policies. Rapid advancements in the technology of fire management, however, offer some applications which may be adaptable to the situation on the Klaserie Private Nature Reserve (Weaver and Benscoter 1989). Specific suggestions are discussed in Chapter 6.

In tandem with bush encroachment there is increasing stress on the grass component and its dependent grazers. Relatively high levels of browse utilisation in habitat types 10 (Acacia nigrescens-Grewia spp.) and 11a (South Western Mixed Woodlands) may mitigate potential bush encroachment somewhat in these types. This is a mixed blessing, however, as it likely indicates a high incidence of mixed feeders, notably impala (Hoffman and Stewart 1972). Close monitoring of the grasses of Klaserie Private Nature Reserve habitats is crucial, particularly in the southern habitat types, 10 (Acacia nigrescens-Grewia spp.), 11a (South Western Mixed Woodlands), 11b (South Eastern Mixed Woodlands), 12 (Combretum apiculatum-Sclerocarya birrea, Grewia

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spp. Short Woodlands with Open Woodland Intrusion) and 13 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Southern Extension).

Habitat type 8 (Western Mixed Woodlands) is also suspected of being impacted on by heavy grazing and requires monitoring. Species-specific impacts, and cumulative interactive impacts on the habitat types are discussed in Chapter 4.

Historical use patterns by game on the Klaserie Private Nature Reserve have altered drastically in a relatively short time frame. This has undoubtedly altered the habitat, possibly permanently. The historical presence of tall grass communities should be investigated further, as well as the current capability of Klaserie habitat types to support tall grass communities. Historical references to sable antelope, as well as their tenuous present status in the Klaserie indicate some remnant of habitat ability for tall grass grazers. This could prove to be an important piece of the puzzle as to the present and potential biological ability of the Klaserie Private Nature Reserve and management activities subsequently designed for it.

Erosion is an ongoing problem that must be addressed at the causative level. Evidence of overutilisation in the southern habitat types, 10 (Acacia nigrescens-Grewia spp.), 11a (South Western Mixed Woodlands), 11b (South Eastern Mixed Woodlands), 12 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodlands with Open Woodland

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Intrusion) and 13 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Southern Extension) is quite clear. Unless this situation is altered it is doubtful that erosion can be arrested entirely. Future erosion control projects must be geared more towards the preventative rather than the reactive and implemented, as a priority, in the above habitat types. In this respect data from this study tend to concur with the body of information from previous studies (Zambatis 1982, 1983, 1985 Schneebeli 1983, Witkowski 1983, Scholes 1987, De Villiers 1989). However, it is prudent to bear in mind that the qualitative vegetation data gathered in this study were determined exclusively by herbivore presence. As such it is likely to represent habitat preferences where the herbivores occur to a greater degree than it represents broad habitat definitions (Hobbs & Hanley 1990). This would explain possible differences with similar data collected solely for vegetative analysis (Appendix A). Overall conclusions, however, do confirm the validity of the current delineation of the Klaserie habitat types and their use in management decision making processes. It does not preclude possible "new" habitat types under different management strategies or fewer types for use under modified herbivore utilisation levels (Edwards 1983).

The predominance of "Increaser II" species noted in Appendix A correlates closely with the herbivore selected findings noted under "DOMINANT GRASS" and "SUBDOMINANT GRASS" (Table 3), and presented to CATMOD as "Variable 36" and "Variable 37" (Table 7). All data currently available indicates an increasingly degraded status for the

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grazing component and validates the diagnosis of a bush encroachment problem on the reserve. Appendix A data, collected in 1988, confirms the impacts on the grazing component as noted in this study, particularly in the grazing types of 10 (Acacia nigrescens-Grewia spp.), 11a (South Western Mixed Woodlands), 11b (South Eastern Mixed Woodlands), 12 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodlands with Open Woodland Intrusion) and 13 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Southern Extension). This is a strong confirmation as the methodology differed considerably from that of the current study. One can only conclude from the body of evidence that severe habitat impacts are occurring on the Klaserie Private Nature Reserve, particularly in the grazing types as outlined in this chapter. Unless current wildlife management practices are altered to reflect this reality the problem will continue to worsen.

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CHAPTER FOUR: HERBIVORE USE PATTERNS

INTRODUCTION

Utilisation of Klaserie Private Nature Reserve habitats by ungulates has previously been monitored by various methods as described in Chapters 2 and 3. Estimates of habitat grazing capacities have, likewise, been piecemeal or compendiums of numerous short-term studies (Schneebeli 1983, De Villiers 1989, Peel 1992). Ungulate biomass estimates (Table 6) by Leibnitz (Pers. Comm.*) based on annual aerial game counts have been a core management ingredient in recent years (Figure 17 and Table 7). Although a study specific to carnivores has been done on the Klaserie Private Nature Reserve (Kruger 1988), no previous comprehensive herbivore-specific study has been undertaken there. The work by Witkowski (1983) incorporates a section on herbivores in the overall ecological relationships of the area, but does not go into any depth. The present study was, therefore, devised to fill the gap between existing habitat use surveys, conducted regularly by the Klaserie Private Nature Reserve management, and more detailed use studies of the herbivores on the reserve conducted by external agencies.

Initially nine types of herbivore (Table 4) were selected as representatives of all possible patterns of utilisation reflective of the whole herbivore biomass on the reserve. Of these, the white rhinoceros was dropped from consideration after sightings were

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Table 6: Calculation of Carrying Capacity for herbivores on the Klaserie Private Nature Reserve, Northern Transvaal for 1992. Source : E.P. Leibnitz, Warden (Pers. Comm./Annual Report).

HERBIVORE	NUMBER	INDIVIDUAL BIOMASS	TOTAL BIOMASS	PERCENT OF TOTAL	FEEDING TYPE
Impala	9,418	43	404,974	14.71	Intermediate grazer
Wildebeest	700	170	119,000	4.32	Primary grazer
Zebra	940	230	216,200	7.85	Primary grazer
Giraffe	943	800	754,400	27.40	Primary browser
Waterbuck	386	160	61,760	2.24	Primary grazer
Buffalo	800	490	392,000	14.24	Primary grazer
Elephant	179	3,300	590,700	21.46	Intermediate grazer
Warthog	984	60	59,040	2.15	Primary grazer
White Rhino	33	1,500	49,500	1.80	Primary grazer
Kudu	619	170	105,230	3.82	Primary browser
	15,002	N/A	2,752,404	100%	

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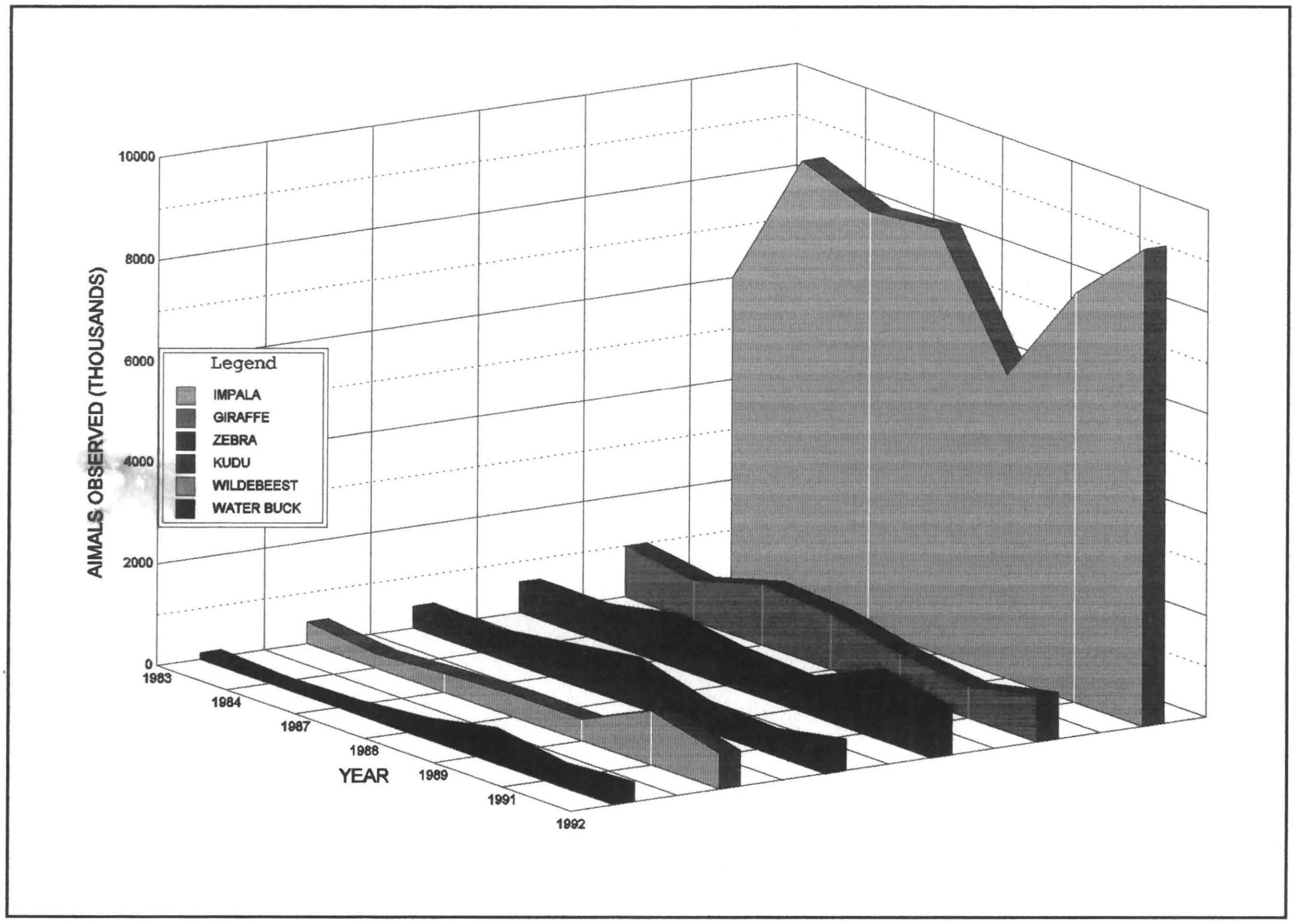

Figure 17: Aerial census of selected herbivores, Klaserie Private Nature reserve, 1983 to 1992 non-inclusive. Note: figures for waterbuck and blue wildebeest are estimates for 1987, no census was conducted in 1985, 1986, or 1990 Data for 1991 are from a helicopter, all other is fixed wing aircraft. Source: Wardens report, Klaserie Private Nature Reserve, Annual General Meeting. Showing recent population trends and preponderance of impala biomass.

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Table 7: Summary of Aerial counts of selected herbivores on the Klaserie Private Nature Reserve, Northern Transvaal, 1983 to 1992, non-inclusive, As displayed in Figure 17. No aerial counts are available for 1985, 1986, or 1990. Data for 1991 are from a helicopter, all other data collected from fixed wing aircraft.

YEAR	IMPALA	GIRAFFE	KUDU	ZEBRA	WATERBUCK	WILDEBEEST
1983	6,000	1,000	425	600	125	425
1984	8,750	800	400	590	50	275
1987	8,250	1,200	600	875	90	375
1988	8,400	1,100	800	675	225	435
1989	6,000	800	425	600	510	425
1991	8,089	624	350	1,225	307	1,066
1992	9,418	943	619	940	386	700

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insufficient to be statistically significant. Population estimates for the white rhinoceros on the Klaserie Private Nature Reserve for the period 1990-1992 were thought to be circa 37. An aerial rhinoceros count in early 1992 yielded only 33 individuals (Table 6). The remaining eight subject types of herbivore are described below with the rationale for their inclusion in this study, The taxonomy after Smith (1985):

ORDER PROBOSCIDEA

Family Elephantidae

Loxodonta africana: African elephant

Rationale: Mixed bulk feeder with great potential impact on the habitat, non-ruminant.

ORDER PERISSODACTYLA

Family Equidae

Equus burchelli: Burchell's or Chapman's zebra

Rationale: Exclusive grazer, non-selective, short and tall grass, non-ruminant.

ORDER ARTIODACTYLA

Family Suidae

Phacochoerus aethiopicus: warthog

Rationale: Concentrate, short grass grazer, forbs, herbs and shrubs, non-ruminant.

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Family Giraffidae

Giraffa camelopardelis: southern giraffe

Rationale: Exclusive browser at highest strata. Plant food selective.

ORDER ARTIODACTYLA

Family Bovidae

Sub-family Alcelaphinae

Connochaetes taurinus: brindled gnu, blue wildebeest

Rationale: "Fresh grass grazer" (Spinage 1986) or concentrate grazer, ruminant, short grass, area selective, narrow ecological abilities.

Sub-Family aepycerotinae

Aepyceros melampus: impala

Rationale: Intermediate or mixed feeder, short grass, area selective.

Sub-Family Bovinae

Syncerus caffer: southern or Cape buffalo

Rationale: Bulk grazer, ruminant, tall grass selective.

Tragelaphus strepsiceros: southern greater kudu

Rationale: Primary browser, lower strata, wide ecological abilities.

The above types of herbivore are all native to the lowveld habitats of South Africa which were and are present on the Klaserie Private Nature Reserve (Stevenson-Hamilton 1929). The species numbers now occurring as well as the presence of some species is considerably different now as compared with historical times (Chapter 3) (Evans

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1979). Other species of herbivores, for which this study is relevant for management purposes, and which occurred during the course of the study include:

ORDER ARTIODACTYLA

Family Hippopotimidae

Hippopotamus amphibius: hippopotamus

Family Bovidae

Sub-family Cephalophinae

Sylvicapra grimmia: common or southern bush duiker

Sub-family Antilopinae

Raphicerus campestris: steenbok

Oreotragus oreotragus: klipspringer

Sub-family Hippotraginae

Hippotragus niger: sable antelope

Sub-family Bovinae

Tragelaphus scriptus: South African bushbuck

Tragelaphus angasii: nyala

Sub-family Reduncinae

Kobus ellipsiprymnus: common waterbuck

These herbivore are also native to the lowveld habitats of South Africa which were and are present on the Klaserie Private Nature Reserve (Stevenson-Hamilton 1929). During the course of this study one observation of an eland Taurotragus oryx was recorded in the Klaserie Private Nature Reserve habitat type 8 (Western Mixed

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Woodlands) (Figure 7). However, this was judged to be a transient individual from an adjacent reserve, as eland are not presently known to occur in the Klaserie Private Nature Reserve. Missing from the list of native herbivores are the extirpated roan antelope, Hippotragus equinus, tsessebe Damaliscus lunatus, reedbuck, Redunca arundinum and the black rhinoceros, Diceros bicornis.

METHODS

Numerous methodologies exist to determine habitat preferences of herbivores and interactions of herbivores with each other and their respective habitats. The specific method chosen is usually dictated by local circumstances, particularly on larger areas (Smuts 1974). Habitat selection is generally predicated on the factors of palatability of and preference for food (Van Hoven and Ebedes 1989). This fact must, therefore, be considered in devising any method of habitat use study.

Deriving quantitative evaluations of herbivore use through observed facets of utilisation and comparisons of these with expected patterns is well documented in the literature (eg: Blankenship and Field 1972; Ferrar and Walker 1974; Hirst 1975; Irwin 1978; Monro 1980; Melquist and Hornocker 1983; Fafarman and deYoung 1986; Fabricus 1989), although weaknesses in such methodologies have been pointed out (Hobbs and Hanley 1990). The circumstances involved in the terrain and size of the Klaserie Private Nature Reserve suggested well placed,

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replicable, transects with repeated observations over time as being the most feasible logistically (Chapter 3).

The methods described in Chapter 3 were used for the collection of all vegetation data in this project. Since vegetation data were collected on the basis of herbivore occurrence, they are reflective of herbivore preferences within the framework of the data definitions. The described survey routes (Figure 8) and subsequent data collection lasted from September 1990 through February 1992. These were done from a light truck with observation details adapted from those used by Wentzel (1989). Speed of travel was adjusted to the individual habitat type and respective to visibility and to the season. Observation speeds in winter tended to be higher than those of summer, mainly because of overall, greater, visibility in the winter months.

Maximum total route length was 40,5 km. and minimum was 8,0 km. as explained in Chapter 3. Only observations taken up to and including 90 degrees from the observer and his direction of travel were included. When the observer was out of the vehicle, subsequent sightings of subject herbivores were recorded if they met these criteria of angle and were no further than 250 m away from the centre of the route. Under no circumstances were observations of animals included if they were behind the 90 degree point of last observation from the observer's position in the centre of the route. Particular care was taken to prevent double-counting of any individuals on a specific day. For example, visually identifiable animals were ignored

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if they were again observed further along a route on the same day. To minimise observer bias further, the route direction was also reversed on alternate surveys. Each route was, therefore, assigned an "A" and a "B" point which became indicative of the direction travelled on a given day.

Optimum hours of observation locally were from dawn until approximately 11:00 (Scogings 1988; Wentzel 1989). Therefore data collection ceased if a transect route was not completed by 12:00. There was only one such instance during the course of this study. Specific herbivore data collected at each observation are displayed in Table 8 as variables, the methodology of its collection was discussed in Chapter 3. The methodology for the collection of non-vegetation data is summarised in Table 9.

Of the initial 55 variables for which data were collected (Table 8), 21 emerged as significant predictors under CATMOD analysis. These were therefore analysed by species, and by season as noted in Chapter 3. The variables from Tables 2 and 5 which were most germane under CATMOD for the subject herbivores are (Appendix B):

Riparian distance: Variable 18, Temperature: Variable 23, Open area: Variable 26, Visibility distance total: Variable 27, Visibility distance to animal: Variable 28, Visibility distance at animal: Variable 29, Utilisation of grasses: Variable 30, Utilisation of browse: Variable 31,

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Table 8: **Data set variable definition as used for computer analysis with the CATMOD Procedure for herbivore/habitat use on the Klaserie Private Nature Reserve, Northern Transvaal, from 1990-1992. Where Variable is item as presented to CATMOD, Item is cell number from LOTUS 123 data sheet, Range is cell content and Column is number of columns used by LOTUS 123 for the data on the original spreadsheet.**

VARIABLE	ITEM	DESCRIPTION	RANGE	COLUMN
V01	A	Date	DDMMYY	01-06
V02	B	Transect number	001-013	08-10
V03	C	Start time	HH:MM	12-16
V04	D	Start point	A/B	18
V05	E	Start odometer	THTU.D	20-25
V06	F	Stop time	HH:MM	27-31
V07	G	End odometer	THTU.D	33-38
V08	H	Row number	01-50	40-41
V09	I	Observation number	01-25	43-44
V10	J	Species	1-9	46
V11	K	Animal number	001-100	48-50
V12	L	Activity	1-5	52
V13	M	Time	HH:MM	54-58
V14	N	Grid number	001-555	60-62
V15	O	Odometer	THTU.D	64-69
V16	P	Water Distance	0001-1000	71-74
V17	Q	Water Temporary	0001-1000	76-79
V18	R	Riparian Distance	0001-1000	81-84
V19	S	Land slope	00/L-45U	86-89
V20	T	Barometer	nn.dd	91-95
V21	U	Elevation	250-600	97-99
V22	V	Cloud cover	105	101
V23	W	Temperature	10-45	103-104
V24	X	Wind	000/H-360/M	106-110
V25	Y	Aspect	000-360	112-114
V26	Z	Open area	Y/N/R	116
V27	AA	Vis Dist total	001-999	118-120

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Table 8: Continued

V28	AB	Vis dist to animal	001-999	122-124
V29	AC	Vis Dist at animal	000-999	126-128
V30	AD	Util grass	1-5	130
V31	AE	Util browse	1-5	132
V32	AF	Phen grass	1-5	134
V33	AG	Phen browse	1-5	136
V34	AH	Grass/forb	100/100	138-144
V35	AI	Bare ground	000-100	146-148
V36	AJ	Dom grass	ABCDE	150-154
V37	AK	Sub-dom grass	ABCDE	156-160
V38	AL	Dom woody	ABCDE	162-166
V39	AM	Sub-dom woody	ABCDE	168-172
V40	AN	Erosion	0-5	174
V41	AO	Ele dam old	00-20	176-177
V42	AP	Ele dam new	00-20	179-180
V43	AQ	Damage spec	ABCDE	182-186
V44	AR	Grass height	nn.n	188-191
V45	AS	Grass height N	nn.n	193-196
V46	AT	Grass height W	nn.n	198-201
V47	AU	Grass height S	nn.n	203-206
V48	AV	Grass Height E	nn.n	208-211
V49	AW	Crown cover	000-100	213-215
V50	AX	Crown cover N	000-100	217-219
V51	AY	Crown cover W	000-100	221-223
V52	AZ	Crown cover S	000-100	225-227
V53	BA	Crown cover E	000-100	229-231
V54	BB	Browse height	nn.n	233-236
V55	BC	Comment	alpha	238-270

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Table 9: Herbivore sighting data, non-vegetation elements. As collected from 1990-1992 on the Klaserie Private Nature Reserve, Northern Transvaal.

SYMBOL	INTERPRETATION
SPECIES	1=Impala, 2=Zebra, 3=Blue wildebeest, 4=Buffalo, 5=Elephant, 6=Kudu, 7=White Rhino, 8=Giraffe, 9=Warthog
TIME	Military style time entry for each observation.
GRID NUMBER	Taken from Klaserie Private Nature Reserve master grid map.
NUMBER OF ANIMALS	Total number per sighting per species.
ACTIVITY	1=Feeding, 2=Watering, 3=Resting, 4=Moving, 5=Other/Unknown
WATER DISTANCE	Distance to nearest permanent water in metres.
TEMPORARY WATER ?	Measurable distance to wet season pan water, if any, in metres.
RIPARIAN DISTANCE	Distance to nearest zone of riparian vegetation, in metres.
BAROMETER	Barometric pressure in inches of Mercury.
ELEVATION	Taken in metres above sea level at the observation point, by altimeter.
CLOUD COVER	Relative cloud cover 1=Clear, 2=Partly cloudy, 3=Mostly cloudy, 4=Overcast, 5=Hazy, 6=Raining.
ODOMETER	Last four digits and decimal reading from vehicle Odometer in kilometres.
TEMPERATURE	Degrees Celsius
WIND	N=None, L=Light, M=Moderate, H=Heavy. Wind direction is in degrees relative to true north and indicating the direction from which the wind is blowing
OPEN AREA	Is sighting in an open area of at least 50 x 50 metres with substantially reduced browse stem densities? Yes or No.
VISIBILITY DISTANCE TOTAL	Total visibility in metres at observation point.
VISIBILITY DISTANCE TO ANIMAL	Visibility in metres to observed animal(s).
VISIBILITY DISTANCE AT ANIMAL	Visibility average from animals perspective.
SLOPE/LAND scale	Clinometer reading in degrees/ Landscape position on a relative L=Lower slope, M=Middle slope, U=upperslope.

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Phenology of browse: Variable 33, Grass/forb ratio: Variable 34, Bare ground: Variable 35, Dominant grass: Variable 36, Sub-dominant grass: Variable 37, Dominant woody: Variable 38, Sub-dominant Woody: Variable 39, Old elephant damage: Variable 41, New elephant damage: Variable 42, Damaged species: Variable 43, Grass height: Variable 44, and Crown cover: Variable 49.

Data Analysis

The sum of the collected data on the vegetation and the herbivores, were subjected to the CATMOD procedure. CATMOD (Categorical data modelling) is a procedure for categorical data modelling. PROC CATMOD (CATMOD Procedure) analyzes data that can be represented by a contingency table. It fits linear models to functions of response frequencies. As such it can be used eg; for linear modelling, log-linear modelling, and logistic regression. CATMOD has shown satisfactory results in lowveld environments for the illustration of mammalian species associations based on the selection of similar habitat factors (Beardall Joubert and Retief 1983).

In the current study, CATMOD was applied by herbivore to each data set. Data specific to each herbivore species were considered individually by its variables. Each herbivore observation entailed up to 55 variables (Table 8). Each prediction variable was compared either individually or as a similar grouping (eg. crown cover) with the herbivore species occurrence and season of observation until it

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was either included as a significant prediction of occurrence, statistically, or excluded as non-significant, statistically (Figure 18). This was based on the output generated by CATMOD and displayed in the maximum likelihood analysis-of-variance table (Greenacre 1984) for each herbivore species data set. Of the predictors, the most salient were identified by their Chi-square and probability calculations included in the tables generated (Appendix B).

Thus a ranking of the most statistically significant predictors was made and is presented under "Results". These were then focused on individually and their effects were further considered, by re-submission to CATMOD until the most significant predictors in the data set emerged or the model collapsed. Re-submissions were made to the point of collapse for each herbivore, by season. The finalised model was the last model yielding significant predictors immediately prior to a model collapse. This particular utilisation of the CATMOD analysis is both time-consuming and unique. No references to such use were found in the literature. However, its highly customised approach by species holds the potential for specific and reliable consideration of individual data set variables (Van der Linde, pers. comm. *) (Groeneveld, pers. comm. **).

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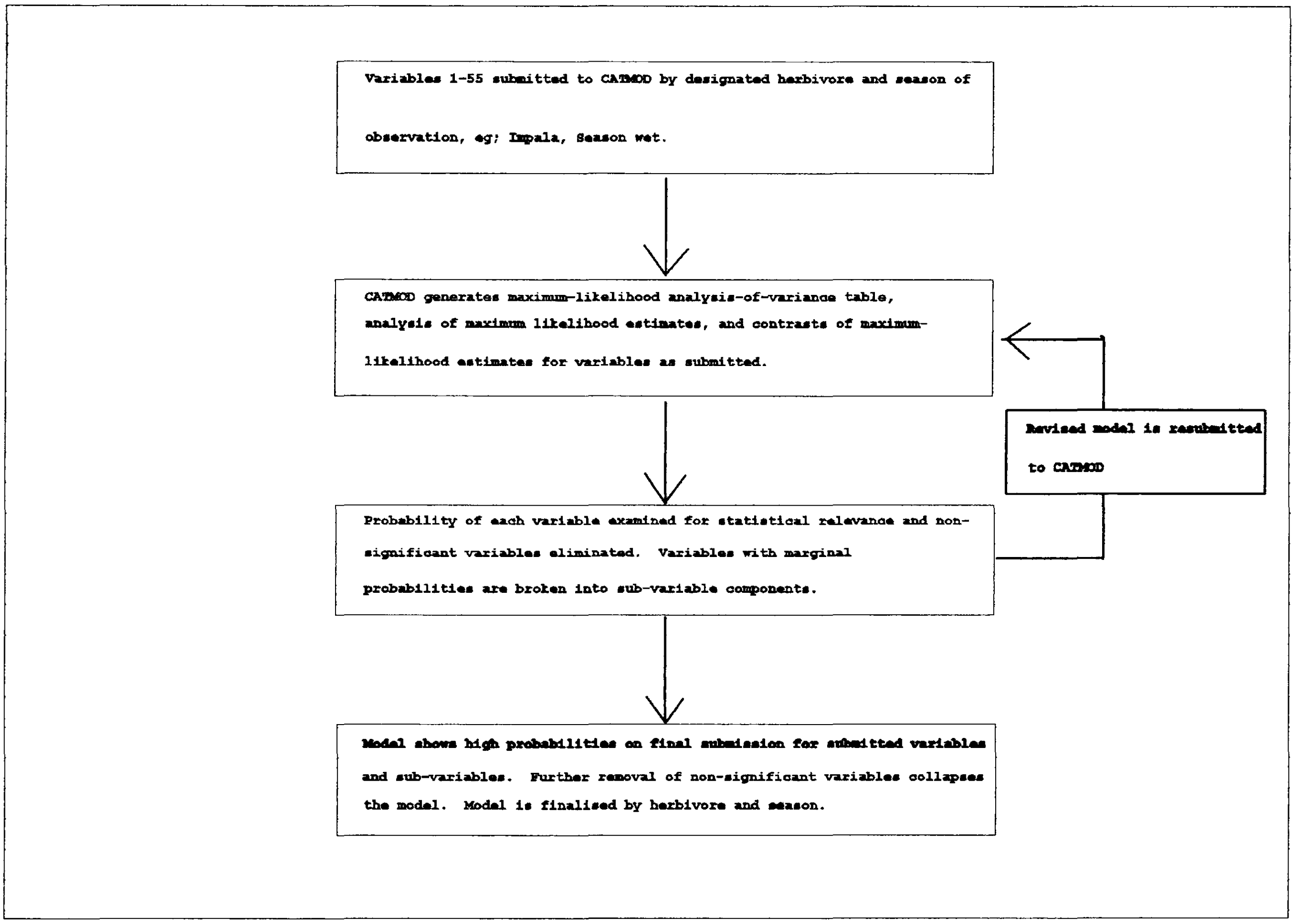

Figure 18: Flow chart illustrating the process involved in submitting data to CATMOD for analysis.

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For example, variables could be up broken into their component parts and the sub-variable sets arranged in differing classes (e.g. Total visibility or variable 27 was broken into differing distance classes such as 100-200 m, >200-400 m, etc.) Variables which then emerged as increasingly significant within each herbivore's sub-variable data set

by CATMOD were reversed in presentation to CATMOD, thus displaying standard deviations and maximum likelihood estimates by sub-variable (Appendix B) as compared to comparable sub-variables sets within the same variable set. Confirmation of significance relative to the subject herbivore and subsequent ordination followed logically.

RESULTS

CATMOD analysis of the herbivore data yielded significant habitat component affinities by the different species and seasons. CATMOD analysis by herbivore species is presented in Appendix B. Table 8 provides the key for interpretation of the variables presented in Appendix B. Since each data set was considered separately and customised according to the significant variables contained therein, as indicated by (Appendix B), the results are highly species specific and are presented as such.

IMPALA

The data set for the impala is the largest of all the herbivores

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studied due to their abundance and consequent number of sightings. Therefore it is also the most statistically significant data set. Data set variables of the greatest significance relative to impala utilisation of Klaserie Private Nature Reserve habitats are discussed below. These tables show the 20 variables which was identified by using CATMOD from the data set which had significance for further analysis; although individual variables examined under CATMOD did not always yield clearly defined relationships. Of the 20 variables which were examined individually, further, the probabilities of each were considered and the conclusive data sets were identified as:

Impala: dry season data

CATMOD analysis was done for the following variables but demonstrated no clear model of dry season impala use with them or any of their components:

Open area: Variable 26, Visibility distance to animal: Variable 28, Visibility distance at animal: Variable 29, Utilisation of browse: Variable 31, Phenology of browse: Variable 33, and Damaged species: Variable 43,

CATMOD analysis established models for impala use and the following variables in the dry season (Appendix B):

Impala are six times more likely to be sighted within 140 m of a zone

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of riparian vegetation than at greater distances away (Probability=0.0078) (Variable 18). Furthermore, impala were twenty two times more likely to be observed when the temperatures were between 11 and 21° C. (Probability=0.0013) (Variable 23). Impala were most likely to be found in areas of increased total visibility, with the least likelihood of occurrence being where total visibility is between 20 and 50 m. (Probability=0.0005) (Variable 27). Impala were also responsive to the visibility from their perspective, being most likely to occur where their visibility is between 10 and 35 m (Odds 157 to 1, probability=0.0000) (Variable 29).

CATMOD analysis also suggests that impala were most likely to occur where utilisation of the grass component exceeded 80 percent of the available annual growth. Impala were 25 times more likely to be found in such heavily utilised situations than in lightly utilised areas (Probability=0.0400) (less than 30% percent utilisation of the annual growth). Impala were also 14 times more likely to be found in the next lower category of utilisation (60 percent to 80 percent) than in an area of light utilisation (less than 30 percent). Impala displayed a clear preference for areas of heavily utilised grass in all Klaserie Private Nature Reserve habitats in the dry season (Probability=0.0214) (Variable 30).

Impala preferred habitat situations where the grass to forb ratio were between 0 and 1,5 (Odds 4 to 1, probability=0.0209) (Variable 34). Impala were also most likely to be found in habitat situations with

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a bare ground reading in excess of 60 percent. Most impala occurrences were in areas with between > 60 percent and 75 percent bare ground. Impala were 270 times more likely to be found in this category than in the next lower category, between 40 percent to 60 percent bare ground (Probability=0.0001). Impala utilisation of situations in excess of 75 percent bare ground varied, however. The chances of finding impala on bare ground in excess of 75 percent were 11 times that of finding them in habitats with a bare ground reading of < 60 percent (Probability=0.0435)(Variable 35).

Impala demonstrated an aversion to habitats where the visually dominant grass was Urochloa mosambicensis. Impala were most likely to occur in habitats where the visually dominant grass was Aristida congesta (Odds 12 to 1, probability=0.0290)(Variable 36). Impala also exhibited a preference for habitats where the visually sub-dominant grass species was Bothriochloa radicans (Probability=0.0000)(Variable 37). Impala were also likely to occur in habitats where Grewia spp. dominated. Impala were > 200 times more likely to occur in such habitats than where Acacia spp. occurred (Probability=0.0002). Impala were 79 times more likely to be found in association with Combretum apiculatum dominated habitats than in those dominated by Acacia spp. (Probability=0.0002) (Variable 38). A definite preference for habitats with Grewia spp. as the sub-dominant woody plant was also demonstrated by impala (Odds 11 to 1, probability=0.0018) (Variable 39).

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Impala showed a preference for association with areas of old elephant damage to trees (Chapter 5). Impala were 11 times more likely to be found in proximity to areas where elephant had killed at least two trees in a 40 m radius in the period of at least 6 months to approximately 15 years before the data were collected than to areas with less damaged trees. (Probability=0.0062) (Variable 41). Conversely impala demonstrated an aversion to habitats where elephants had killed no trees within the previous six months (Odds 44 to 1, Probability=0.0003) (Variable 42). Dry season habitats preferred by impala also had disc pasture meter readings in excess of 2,8 (Odds 9 to 1, probability=(0.0099)(Variable 44).

Lack of canopy cover, or shade, proved to be a significant variable according to the CATMOD analysis. The greatest likelihood of locating impala was in habitats where a canopy cover of less than 2 percent was the norm. Impala were 169 times more likely to be found in such habitats than in those with canopy cover between 2 percent and < 8 percent (Probability=0.0000). Impala were next most likely to be found in habitats with a canopy cover between > 8 percent and < 44 percent. A canopy cover of < 8 percent to 2 percent was 19 times less likely to contain impala than one with a canopy cover of 8 to <44 percent (Probability=0.0021)(Variable 49).

Impala: wet season data.

CATMOD analysed showed the following variables to have no clear model

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of wet season impala use:

Temperature: Variable 23, Utilisation of browse: Variable 31, Phenology of browse: Variable 33, and Dominant grass: Variable 36.

CATMOD analysis established models for impala use in the wet season and the following variables (Appendix B):

Impala displayed a clear preference for wet season proximity to zones of riparian influence. Impala were most likely to be found in areas with a proximity of between 40 to 175 m away from the nearest riparian vegetation (Odds 1142 to 1, probability=0.0.0002)(Variable 18).

Impala preferred open areas in the wet season. Open areas in this study were defined as having a visually reduced density of browse species, in comparison with the mean densities in the specific vegetation type, and being at least 50 m in diameter. Impala were 519 times more likely to be found in such an area than in adjacent areas more reflective of the mean bush density present on the Klaserie Private Nature Reserve (Probability=0.0004) (Variable 26). The visibility from the observer to the animal was between 35 and 55 m in wet season habitats preferred most by impala (Odds 282 to 1, probability=0.0001) (Variable 28). The visibility from the animals perspective in such preferred habitats was between 5 and 30 m (Odds 1,449,236 to 1, Probability=0.0000) (Variable 29).

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Impala were most often found in habitats where the utilisation of grasses was in the lighter categories of 1 (0-30%) and 2 (>30-60%). Such utilisation being defined has less than 60 percent of the available annual growth being consumed (Odds 5209 to 1, probability=0.0010) (Variable 30). Impala also showed an affinity to habitats where the grass to forb ratio was between 1,5 and 100,0 (Odds 84 to 1, probability=0.0004) (Variable 34). Furthermore, impala preferred habitats with bare ground percentages of between 0 and 25 percent (Odds 793 to 1, probability=0.0171) (Variable 35).

Wet season habitat use by impala was least likely to be in habitats where the visual sub-dominant grass was Bothriochloa radicans (Probability=0.0003) (Variable 37). But impala showed a preference for wet season habitats where the visually dominant woody species was Colophospermum mopane (Odds 174,319, probability=0.0000) (Variable 38).

Impala use in the wet season was most likely in an area where at least two trees per 40 m radius had suffered damage by elephants more than six months before the data collection (Odds 2,071,660 to 1, probability=0.0000) (Variable 41). Similarly impala showed a preference for areas of new elephant damage with at least one tree killed per 40 m radius (Odds 2315 to 1, probability=0.0117) (Variable 42). Impala were most likely to occur in habitats where the dominant tree killed by elephants was Sclerocarya birrea (Probability=0.0002) (Variable 43).

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Impala were also most likely to occur in those parts of their habitats where the crown cover was between 8 and 15 percent (Odds 160 to 1, probability=0.0134) (Variable 49).

ZEBRA

Data set variables of the greatest significance relative to zebra utilisation of Klaserie Private Nature Reserve habitats are discussed below. These show the 16 variables which was identified using CATMOD which had significance for further analysis. Of these 16 variables, the probabilities of each were then individually examined and the conclusive data sets are given below:

Zebra: dry season data

CATMOD analysed the following variables but demonstrated no clear model of dry season zebra use with these variables or any of their components:

Open area: Variable 26, Visibility distance total: Variable 27, Dominant grass: Variable 36, Sub-dominant grass: Variable 37, Dominant woody: Variable 38, Sub-dominant Woody: Variable 39, and New elephant damage: Variable 42.

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CATMOD analysis established models for zebra use in the dry season and the following variables (Appendix B):

Zebra were most likely to be observed where the distance from the observer to the animal was between 40 and 225 m.(Odds 15 to 1, probability=0.0003)(Variable 28). Zebras were also most likely to be observed in habitat situations where the visibility distance from the animals perspective was between 10 and 45 m (Odds 4 to 1, probability=0.0315)(Variable 29).

The zebras on the Klaserie Private Nature reserve were most likely to occur where utilisation of the grass component was > 80 percent of the available annual growth. Zebras were 79 times more likely to be found in such a heavily utilised situation than in the next lower category of utilisation (60 to 80 percent). CATMOD analysis indicates that there was no chance of this association occurring by accident (Probability=0.0018). The zebra, therefore, showed a clear preference for heavily utilised grass habitats in all Klaserie Private Nature Reserve habitats in the dry season (Variable 30)(Appendix B).

Zebras showed a distinct affinity for habitat situations where the grass to forb ratio is between 1,5 and 9 (Odds 59 to 1, probability=0.0000)(Variable 34). Zebras also showed a preference for habitat situations where bare ground percentages were between 50 and 75 percent (Odds 11 to 1, probability=0.0045)(Variable 35). Zebra show a distinct affinity for those habitat situations where Urochloa

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mosambicensis was the visually sub-dominant species (Odds 39 to 1, probability=0.0027) (Variable 37). Zebra were also more likely to utilise habitat situations where old (more than 6 months to approximately 15 years) elephant induced tree mortality of 3 trees within a 40 m radius were present. Zebras were 10 times more likely to be found in association with one such mortality than in the higher category (>3 to 7 trees killed within a 40 m radius) (Probability=0.0298) (Variable 41). Zebra also show a preference for habitats where elephants inflict the highest mortality on Acacia spp. trees. Zebras were > 300 times more likely to be found in association with such mortality than in areas where elephant damage consists primarily of Combretum apiculatum (Probability=0.0271) (Variable 43).

Zebra showed an affinity for habitat areas where disc pasture meter readings were between 2,8 and 4,0. They were more likely to be found in such areas than where higher or lower readings occur (Odds 28 to 1, probability=0.0001) (Variable 44). Dry season zebra use was most likely to occur in areas of low crown cover. Use was most likely to occur in areas of between 1 and 6 percent than in areas of higher canopy closure (Odds 12 to 1, probability=0.0056) (Variable 49).

Zebra: wet season data.

CATMOD analysed the following variables but demonstrated no clear model of wet season zebra use with these variables or any of their components:

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Grass/forb ratio: Variable 34, Dominant grass: Variable 36, Dominant woody: Variable 38, and Grass height: Variable 44.

CATMOD analysis established models for zebra use in the dry season and the following variables (Appendix B):

Wet season zebra use of Klaserie Private Nature Reserve habitats was most likely to occur in those areas classified here as open. Open areas in this study had a visually reduced density of browse species, relative to the mean browse plant densities in the specific vegetation type, in areas of at least 40 m in diameter. Zebra were 35 times more likely to use such areas than adjacent areas of denser cover (Odds 35 to 1, probability=0.0248)(Variable 26).

Zebra were most likely to use wet season habitats where were within 40 to 60 m of a bush track or graded road (Odds 15,641 to 1, probability=0.0002)(Variable 28). Zebras were most often observed in habitat situations where the visibility from the animals perspective was between 5 and 70 m (Odds 199,759 to 1, probability=0.0033)(Variable 29).

Zebra were clearly more associated with areas of heavy to excessive grass utilisation than in areas of light to moderate use (Odds 2,693 to 1, probability=0.0053) (Variable 30). Zebra were also much more likely to be found in areas with a high bare ground percentage, than in areas of more ground cover. Zebra concentrated in areas of between

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50 to 100 percent bare ground with most use occurring where bare ground readings were >70 percent (Odds 97 to 1, probability=0.0060) (Variable 35).

Zebras showed a clear preference for habitat situations where either Bothriochloa radicans (Odds 14,119 to 1, probability=0.0059) or Eragrostis rigidior (Odds 14,119, probability=0.0005) were the visual sub-dominant grass species (Variable 37).

Zebras showed a marked preference for habitat situations where the visual sub-dominant woody species was Acacia spp.(Odds 2,709 to 1, probability=0.0021). A discernable secondary preference was exhibited for situations where Combretum apiculatum was the visual sub-dominant woody plant (Odds 567 to 1, probability=0.0159)(Variable 39).

Zebras showed a wet season habitat preference for area where old (more than 6 months to about 15 years prior to data collection) elephant-induced tree mortalities of 2 individuals within a 40 m radius were present (Variable 41). Zebras also showed a wet season habitat preference for areas where new (less than 6 months prior to data collection) elephant-induced tree mortalities of 2 or more individuals were present in a radius of 40 m from the observation plot centre (Odds 202 to 1. probability=0.0495)(Variable 42). And showed a clear preference for wet season habitat areas where elephant induced tree mortality were focused on Sclerocarya birrea (Odds 5,003 to 1, probability=0.0495)(Variable 43).

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Zebras preferred wet season habitats with a heavy woody canopy cover. Preference was skewed towards increasingly heavier canopy cover with preference directed towards areas with a crown cover of between 28 and 80 percent (Odds 61 to 1, probability=0.0253)(Variable 49).

BLUE WILDEBEEST

Data set variables of the greatest significance relative to blue wildebeest utilisation of Klaserie Private Nature Reserve habitats are displayed in Appendix B. These data show the 20 dry season and 19 wet season variables which were identified with the use of CATMOD analysis from the data set to have significance for further analysis. Of these variables the probabilities of each were then individually examined and the results are:

Blue Wildebeest: dry season data

The following variables showed no correlation of dry season blue wildebeest use with these variables or any of their components (Appendix B):

Temperature: Variable 23, Open area: Variable 26, Utilisation of browse: Variable 31, Phenology of browse: Variable 33, Grass/forb ratio: Variable 34, Sub-dominant Woody: Variable 39, and New elephant damage: Variable 42.

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However, a significant correlation existed between blue wildebeest use in the dry season and the following variables (Appendix B):

Blue wildebeest were 100 times more likely to be found at distances greater than 150 m from a zone of riparian vegetation during the dry season than at distances under 150 m (Probability=0.022) (Variable 18). Blue wildebeest were most likely to occur in dry season habitats where the total visibility was between 90 and 350 m. In such situations the wildebeest were >200 times more likely to occur than in situations where the total visibility was <90 m (Probability=0.0040) (Variable 27). Blue wildebeest were 17 times more likely to be found at distances of between 40 and 225 m from an established bush track or graded road than at lesser distances (Probability=0.0266)(Variable 28) and were also most likely to be sighted where visibility from the animals perspective was between 40 and 300 m (Probability=0.0536)(Variable 29).

Blue wildebeest were most likely to be found in dry season habitats where bare ground percentages were between 10 and 40 percent, and they were least likely to be found in areas with 85 to 100 percent bare ground (Odds 219 to 1, probability=0.0148) (Variable 35).

The blue wildebeest on the Klaserie Private Nature Reserve had a clear affinity for areas of habitat where Aristida congesta was the visually dominant grass species (Odds 3, 699 to 1). CATMOD analysis showed that there is no probability that this association occurs by chance

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(0.0004) (Variable 36). Blue wildebeest were also most likely to be found in habitats where the sub-dominant grass species was Aristida congesta (Odds 59 to 1, probability=0.0138)(Variable 37), and further, showed a dry season preference for habitats where the visually dominant woody plant was Grewia spp. (Odds 1077 to 1, probability=0.0048)(Variable 38). Blue wildebeest showed a preference for habitats where old elephant damage (tree mortality at least six months before the data were collected) of at least one tree within a 40 m radius occurred (Odds 25 to 1, probability=0.0373)(Variable 41), and demonstrated a dry season habitat preference for those areas with a mean disc pasture meter reading of between 2,8 and ≤4,0. Blue wildebeest were least likely to be found where the disc pasture meter readings were more than >4,0 to 11,3 (Odds 332 to 1, probability=0.0077)(Variable 44). Blue wildebeest, furthermore showed a clear dry season preference for those areas with the most dense crown cover readings. Blue wildebeest were most likely to occur in habitats of at least 6 percent tree canopy cover and least likely to occur in those areas with <1 percent. Use likelihood was greatest in habitats of between 6 and 44 percent canopy cover (Odds 63 to 1, probability=0.0304) (Variable 49).

Blue wildebeest: wet season data

CATMOD analysed the following variables but demonstrated no clear model of wet season blue wildebeest use with these variables or any of their components:

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Riparian distance: Variable 18, Open area: Variable 26, Visibility distance total: Variable 27, Visibility distance to animal: Variable 28, Visibility distance at animal: Variable 29, Utilisation of browse: Variable 31, Bare ground: Variable 35, Dominant grass: Variable 36, Dominant woody: Variable 38, Dominant woody plant: Variable 39, and Grass height: Variable 44.

CATMOD analysis established models for blue wildebeest use in the wet season and the following variables (Appendix B):

Blue wildebeest were most likely to be found in areas where the total visibility exceeded 60 m (Odds 352,908,869 to 1, probability=0.0061) (Variable 27). Further, they were most likely to use areas where the visibility from the animals perspective exceeded 15 m (Odds 1,812,804,936 to 1, probability=0.0054)(Variable 28).

Blue wildebeest were also most often found in areas showing heavy utilisation of the grass component, being found most in areas where such utilisation was >60 percent of the available grass biomass (Odds 62,570,466,155 to 1, probability=0.0102)(Variable 30). The CATMOD analysis also shows a clear dry season correlation to later phenological stages (eg; full leaf, dormant) for blue wildebeest use on Klaserie Private Nature Reserve habitats (Odds 782,002 to 1, probability=0.0284)(Variable 33). The blue wildebeest use of areas of Klaserie Private Nature Reserve habitats where the grass to forb ratio was high(Odds 2,650 to 1, probability= 0.0088)(between 2,4 and

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100) (Variable 34).

The Klaserie blue wildebeest showed a significant preference for habitats in which Eragrostis rigidior was the visually sub-dominant grass species (Odds 625,750,466,155 to 1, probability=0.0066) (Variable 37). Blue wildebeest, furthermore, clearly preferred habitats in which elephant-induced tree mortality, both "old" and "new" has occurred. Heaviest blue wildebeest use correlated with heavy past, old, elephant damage to the mature tree component, 2 to 7 trees within a 40 m radius have been killed in the period from 6 months to about 15 years before the use(Odds 29,557 to 1, probability=0.0065)(Variable 41). Blue wildebeest also preferred habitats in which "new" elephant-induced tree mortality, occurring less than 6 months prior to observation, had occurred. Heaviest blue wildebeest use correlated with "new" elephant damage to the mature tree component. Blue wildebeest were most likely to be found where 1 to 9 trees had been killed within a 40 m radius in the previous six months (Odds 74,482,416 to 1, probability=0.0055)(Variable 42).

Blue wildebeest showed a preference for habitats in which the elephants damaged Combretum apiculatum (Odds 237,400 to 1, probability=0.0082) (Variable 43). Blue wildebeest also showed a preference for wet season habitats characterized by a tree canopy cover of between 22 and 80 percent (Odds 8064054493 to 1, probability=0.0067)(Variable 49).

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CAPE BUFFALO

Data set variable results of the greatest significance relative to buffalo utilisation of Klaserie Private Nature Reserve habitats are given below. These all are significant based on the CATMOD analysis. Although individual variables examined with CATMOD did not always yield clearly defined relationships. Of the 12 dry season and 16 wet season variables which were individually examined, the probabilities of each were considered and the conclusive data sets are:

Cape buffalo: dry season data

CATMOD analysed the following variables but demonstrated no clear model of dry season buffalo use with these variables or any of their components:

Temperature: Variable 23, Visibility distance total: Variable 27, Visibility distance to animal: Variable 28, Visibility distance at animal: Variable 29, Sub-dominant Woody: Variable 39, Old elephant damage: Variable 41, and New elephant damage: Variable 42, Damaged species: Variable 43, Grass height: Variable 44, and Crown cover: Variable 49.

CATMOD analysis established models for buffalo use in the dry season and the following variable (Appendix B):

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Buffalo were most likely to be found at distances between 25 and 1 100 m from a zone of riparian vegetation. Buffalo were >600 times more likely to be found at distances from riparian zones of between 25 and 1 100 m than at lesser distances(Odds 618 to 1, probability=0.0501) (Variable 18).

Cape buffalo: wet season data

CATMOD analysed the following variables but demonstrated no clear model of dry season buffalo use with these variables or any of their components:

Temperature: Variable 23, Visibility distance at animal: Variable 29, Grass to forb ratio: Variable 34, Dominant grass: Variable 36, Sub-dominant grass: Variable 37, Dominant woody: Variable 38, Old elephant damage: Variable 41, New elephant damage: Variable 42.

CATMOD analysis established models for buffalo use in the wet season and the following variables (Appendix B):

Buffalo were most likely to be found within 30 m of a zone of riparian vegetation during the wet season (Odds 397,322 to 1, probability=0.0010)(Variable 18), and in areas with clear visibility. Preferential use occurred in areas where total visibility was greater than 60 m (Odds 1,566 to 1, probability=0.0277) (Variable 27). Buffalo were also most likely to occur at distances of between 5 and

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40 m from a graded road or bush track during the wet season (Odds 230 to 1, probability=0.0143)(Variable 28), in areas where grass utilisation falls into the heaviest use categories of 4 and 5 (>60%) (Odds 20,958,859,487 to 1, probability=0.0015) (Variable 30).

Buffalo preferred wet season habitats where the percentage of bare ground was from 10 to 75 percent (Odds 2,370 to 1, probability=0.0074) (Variable 35). Buffalo were most commonly observed in areas where Acacia nigrescens (Odds 216,134 to 1, probability=0.0225) or Acacia spp. (Odds 8 to 1, probability=0.0030) were the visually sub-dominant woody plant (Variable 39).

Buffalo also prefer wet season habitats where disc pasture meter readings were between 2,6 and 3,9 (Odds 487 to 1, probability=0.0244) (Variable 44), and areas where crown cover was between 14 percent and 44 percent (Odds 80 to 1, probability=0.0262) (Variable 49).

ELEPHANT

Data set variables of the greatest significance relative to elephant utilisation of the Klaserie Private Nature Reserve habitats appear in Appendix B. These show the 10 dry and 10 wet season variables which were identified with CATMOD from the data set as having significance for further analysis; although individual variables examined under CATMOD did not always yield clearly defined relationships. Of the 10 variables which were examined individually, the probabilities of

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each were considered and the conclusive data sets are:

Elephant: dry season data

CATMOD analysed the following variables but demonstrated no clear model of dry season elephant use with these variables or any of their components:

Temperature: Variable 23, Visibility total: Variable 27, Visibility distance to animal: Variable 28, Dominant grass: Variable 36, and Dominant woody: Variable 38.

CATMOD analysis established models for elephant use in the dry season and the following variables (Appendix B):

Elephants were 197 times more likely to be found in dry season habitats where the nearest area of riparian vegetation was more than 140 m away than at lesser distances (Odds 197 to 1, probability =0.0293)(Variable 18). Elephants, furthermore, showed a preference for habitats where the visibility was between 60 and 300 m from the animals perspective. (Odds 42 to 1, probability 0.0569)(Variable 29).

Elephants showed a dry season preference for habitats where the visually sub-dominant woody plant was one of the <u>Acacia</u> spp. (Odds 101 to 1, probability=0.0093) (Variable 39), and were found in habitats where elephant-induced tree mortality, occurring more than 6 months

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prior to observation, had occurred. Current elephant use correlated with past elephant damage to the mature tree component. Elephant were most likely to be found in areas where 1 to 7 trees, in a 40 m radius of the observation plot, had been killed by past elephant use (Odds 65 to 1. probability=0.0512) (Variable 41). Elephants also showed a distinct preference for habitats where the crown cover was between 24 and 44 percent (Odds 1643 to 1, probability=0.0079) (Variable 49).

Elephant: wet season data

CATMOD analysed the following variables but demonstrated no clear model of wet season elephant use with these variables or any of their components:

Visibility distance total: Variable 27, Visibility distance to animal: Variable 28, Visibility distance at animal: Variable 29, Bare ground: Variable 35, Dominant grass: Variable 36, Sub-dominant grass: Variable 37, Dominant woody: Variable 38.

CATMOD analysis established models for elephant use in the wet season and the following variables (Appendix B):

Elephants were most likely to be observed in habitats where the visibility from the animal's perspective was between 20 and 40 m (Odds 10 to 1, probability=0.0042) (Variable 28). They were also most commonly found in association with habitats where the percentage of

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bare ground was relatively low (10 to 20 percent) (Odds 32 to 1, probability=0.0000) (Variable 35).

Elephants showed a distinct preference for habitat types where Sclerocarya birrea was the sub-dominant woody plant. Elephant were 14 times more likely to be found in such types during the wet season than in the next most frequent habitat which was sub-dominated by Grewia spp. (Probability=0.0030) (Variable 39). Elephant were shown to use areas where they had damaged trees 6 months to 15 years prior to the observation. In such areas they were most likely to be found where 2 trees had been damaged in a 40 m radius of the observation point, than in areas of fewer or more damaged trees (Odds 10 to 1, probability=0.0233) (Variable 41). Elephants were also shown to exhibit an affinity for areas of canopy cover of 24 to 80 percent (Odds 5 to 1., probability=0.0222) (Variable 49).

KUDU

Data set variables of the greatest significance relative to kudu utilisation of the Klaserie Private Nature Reserve habitats are discussed below. These showed the 17 dry season and 15 wet season variables which were identified with CATMOD from the data set which had significance for further analysis; although individual variables examined under CATMOD did not always yield clearly defined relationships. Of the 17 dry season and 15 wet season variables which were individually examined, the probabilities of each were

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considered and the conclusive data sets are:

Kudu: dry season data

CATMOD analysed the following variables but demonstrated no clear model of dry season kudu use with these variables or any of their components (Appendix B):

Temperature: Variable 23, Open area: Variable 26, Phenology of browse: Variable 33, Grass/forb ratio: Variable 34, Bare ground: Variable 35, Sub-dominant Woody: Variable 39, Damaged species: Variable 43, and Crown cover: Variable 49.

CATMOD analysis established models for kudu use in the dry season and the following variables (Appendix B):

Kudu showed a distinct affinity for zones of riparian vegetation during the dry season. Kudu were 49 times more likely to be found within 40 m of such vegetation than at greater distances (Probability =0.0160)(Variable 18). Kudu were also most likely to be found in areas of reduced habitat visibility, showing a preference for areas where the total visibility was between 20 and 90 m (Probability =0.0086)(Variable 27). Kudu were most likely to be sighted at distances of between 5 and 40 m from a graded road or bush track (Odds 606 to 1, probability=0.0098)(Variable 28). Furthermore they were most likely to occur in dry season habitats where the visibility was

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between 35 and 50 m from the animal's perspective (Odds 228 to 1, probability=0.0062) (Variable 29).

Kudu were by far, 134 times, more likely than not to occur in areas where browse utilisation was noticeable, than in areas of under-utilisation or no utilisation (probability=0.0092) (Variable 31), and they showed a marked preference (125 times more likely than not to occur) in habitats where the dry season visually dominant woody plant was Combretum apiculatum (Probability=0.0105)(Variable 38).

Kudu in the study showed an affinity (136 times more likely than not) to occur in habitats where old, > 6 months to about 15 years, elephant induced mortality of the mature tree component was very low to non-existent (<1 tree) (Probability=0.0077)(Variable 41). Furthermore, they avoid habitats where new, ≤6 months, elephant induced mortality of the mature tree component occurred (Odds 294 to 1, probability=0.0077) (Variable 42).

Kudu also showed a preference for higher grass readings as taken with a disc pasture meter. They were 587 times more likely than not to be found where readings were between 3,9 and 11,3 than in areas with lower readings (Probability=0.0028)(Variable 44).

Kudu: wet season data.

CATMOD analysed the following variables but demonstrated no clear

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model of wet season kudu use with these variables or any of their components:

Riparian distance: Variable 18, Temperature: Variable 23, Visibility distance total: Variable 27, Utilisation of browse: Variable 31, Grass/forb ratio: Variable 34, Sub-dominant Woody: Variable 39, New elephant damage: Variable 42, and Grass height: Variable 44.

CATMOD analysis established models for kudu use in the wet season and the following variables (Appendix B):

Wet season kudu sightings were most likely to occur at distances in excess of 50 m from the observer (Odds 60 to 1, probability=0.0252) (Variable 28). In the wet season kudu were most likely to be found in areas where the visibility from the animal's perspective was from 5 to 35 m (Odds 34 to 1, probability=0.0215) (Variable 29). Kudu were also most likely to utilise habitats with bare ground percentages of between 30 and 60 (Odds 23 to 1, probability=0.0592) (Variable 35).

Kudu showed a wet season preference for habitats where the wet season visually dominant woody plant was Combretum apiculatum (Probability=0.0219) (Variable 38). Kudu also showed an affinity for habitats where old, > 6 months, elephant-induced mortality of the mature tree component was low (1 tree or less in a 40 m radius of the observation plot). They were 57 times more likely to be found in such habitats than in adjacent habitats with higher tree mortality rates

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(Probability=0.0509) (Variable 41). Kudu also showed a preference for habitats in which elephant-induced mortality on the mature tree component mainly involves Combretum apiculatum (Probability 0.0135)(Variable 43). Kudu demonstrated a distinct affinity for areas of increasing crown cover percentages. Kudu were most likely to occur in areas with crown cover of between 17 and 80 percent. Kudu were 47 times more likely to utilise habitats within these parameters than habitats with a lesser canopy cover (Probability=0.0338)(Variable 49).

GIRAFFE

Data set variables of the greatest significance relative to giraffe utilisation of Klaserie Private Nature Reserve habitats are discussed below. These show the 17 dry season and 20 wet season variables which was identified by the CATMOD analysis from the overall data set which had significance for further analysis; although individual variables examined with CATMOD did not always yield clearly defined relationships. Of the variables which were individually examined, the probabilities of each were considered and the conclusive data sets are (Appendix B):

CATMOD analysed the following variables but demonstrated no clear model of dry season giraffe use with these variables or any of their components:

Giraffe: dry season data

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Bare ground: Variable 35, Dominant grass: Variable 36, New elephant damage: Variable 42, Damaged species: Variable 43.

CATMOD analysis established models for giraffe use in the dry season and the following variables (Appendix B):

Giraffe were most likely to be observed when temperatures were between 23 and 36° C (Odds 15,720 to 1, probability=0.0182) (Variable 23), and were most likely to be located by the observer when the visibility was between 150 and 350 m from the centre of the route (Odds 14,220,534,974 to 1, probability=0.0267) (Variable 27). Giraffe were also most likely to be observed in habitat areas where they were 40 to 70 m from the observer (Probability=0.0079) (Variable 28). In such habitats the giraffe were usually in a situation where visibility of between 90 and 300 m was the norm from their perspective (Odds 6 to 1, probability=0.0095)(Variable 29).

Giraffe showed a preference for areas of heavy browse utilisation. Based on CATMOD, giraffe were increasingly likely to be present as the degree of utilisation pressure on the available browse increases. The greatest likelihood of giraffe presence was in habitats where heavy utilisation categories, between 2 and 4, (>30 to 100 percent) were present (Odds 4,149 to 1, probability=0.0307) (Variable 31). Analysis using CATMOD also shows a distinct correlation between early phenological stages of the vegetation and dry season utilisation by giraffe of such habitats (Probability=0.0435)(Variable 33).

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Giraffe were most likely to occur in habitats where the grass to forb ratio was between 1,5 and 4,0 (Odds 6,293 to 1, probability =0.0200)(Variable 34). Giraffe showed a direct correlation with areas where Panicum maximum was the visually sub-dominant grass species (Odds 1,958 to 1, probability= 0.0556) (Variable 37). They were also most likely to be found in habitats where Combretum apiculatum was the dominant woody plant species (Odds 50 to 1, probability =0.0047)(Variable 38). Furthermore giraffe showed a preference for habitats where the visual sub-dominant woody species was either Combretum apiculatum (odds 152,473 to 1, probability=0.0036)or Acacia nigrescens (Odds 3,461,260,189 to 1, probability=0.0083)(Variable 39).

Giraffe avoided areas of old, > 6 months to about 15 years, elephant-induced mortality of the mature tree component(Odds 52,821 to 1, probability=0.0538) (Variable 41). Giraffe also showed a preference for habitats where the mean crown canopy closure was between 12 and 44 percent (Odds 106 to 1, probability=0.0562)(Variable 49).

Giraffe: wet season data

CATMOD analysed the following variables but demonstrated no clear model of wet season giraffe use with these variables or any of their components:

Total visibility: Variable 27, Visibility distance to animal: Variable 28, Visibility distance at animal: Variable 29, Phenology of Browse:

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Variable 33, Grass/forb ratio: Variable 34, Bare ground: Variable 35, Dominant grass: Variable 36, Dominant woody: Variable 38, Sub-dominant woody: Variable 39, Damaged species: Variable 43, and Disc-pasture meter reading: Variable 44.

CATMOD analysis established models for giraffe use in the wet season and the following variables (Appendix B):

Giraffe were most likely to occur at distances of 150 m or less from zones of riparian vegetation (Odds 264, 810 to 1, probability=0.0014)(Variable 18). Giraffe sightings were most likely to occur at ambient temperatures of between 28 and 38° C (Odds 729 to 1, probability=0.0036)(Variable 23).

Giraffe habitat use was correlated directly with areas which were not defined as open for the purposes of this study (Odds 408,505 to 1, probability=0.0007) (Variable 26), and used habitats where the lightest utilisation of the grazing component occurred present (0 to 30 percent) (Odds 71,134,975 to 1, probability=0.0007) (Variable 30).

Giraffe showed a preference for areas of increasingly heavy browse utilisation. According to CATMOD analysis, giraffe were increasingly likely to be present as the utilisation of the available browse increased. The greatest likelihood of giraffe presence was found in habitats where utilisation categories of between 2 and 4 were recorded (>30 to 100 percent) (Odds 1,751,128 to 1, probability

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=0.0035)(Variable 31).

Giraffe showed a direct correlation with areas where Panicum maximum was the visually sub-dominant grass species (Odds 11,146 to 1, probability=0.0071)(Variable 37), and were most likely to occur where "old" elephant damage, > 6 months old to about 15 years, of the mature tree component occurred at a rate of between 3 and 7 trees within a radius of 40 m (Odds 52,432 to 1, probability=0.0092)(Variable 41), and were also most likely to occur where "new" elephant damage, $\leq$ 6 months old, of the mature tree component has occurred at a rate of between 1 and 6 trees within a 40 m radius (Odds 123,303,784 to 1, probability=0.0001)(Variable 42). Giraffe show an affinity for habitats with a mean tree crown cover of between 10 and 80 percent (Odds 527 to 1, probability=0.0108) (Variable 49).

WARTHOG

Data set variables of the greatest significance relative to warthog utilisation of Klaserie Private Nature Reserve habitats are discussed below. These show the 20 dry season and 20 wet season variables which were identified using CATMOD analysis from the data set which had significance for further analysis; although individual variables examined under CATMOD did not always yield clearly defined relationships. Of the 20 variables which were examined individually, the probabilities of each were considered and the conclusive data sets were (Appendix B):

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Warthog: dry season data.

CATMOD analysed the following variables but demonstrated no clear model of dry season warthog use with these variables or any of their components:

Temperature: Variable 23, Utilisation of browse: Variable 31, Phenology of browse: Variable 33, Sub-dominant grass: Variable 37, Dominant woody: Variable 38, New elephant damage: Variable 42, Damaged species: Variable 43, and Crown cover: Variable 49.

CATMOD analysis established models for warthog use in the dry season and the following variables (Appendix B):

Warthog showed an inverse relationship with the proximity of zones of riparian vegetation. Warthog were most likely to be found in habitats where the nearest zone of riparian vegetation was between 150 and 250 m. Warthog were least likely to be found within 50 m of a zone of riparian influence (Odds 11 to 1, probability=0.0473)(Variable 18). Warthog exhibit a clear preference for habitats which are defined as open (an area of at least 50 m by 50 m with noticeably reduced stem densities for the woody species in relation to adjacent areas). Warthog were 7177 times more likely to occur in such an area as in an adjacent, more dense, habitat (Probability=0.0001)(Variable 26).

Warthog presence was related directly to areas of greater visibility.

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Warthog and they were most likely to occur in habitats where total visibility was between 110 and 350 m (Odds 22 to 1, probability=0.0333)(Variable 27). Warthog were most likely to be sighted at distances of between 45 and 225 m from a bush track or graded road(Odds 25 to 1. probability=0.0130)(Variable 28). Warthog were, also, most likely to be sighted in habitats where the visibility from the warthog's perspective (ground level) was from 40 to 300 m (Probability=0.0000)(Variable 29).

Warthog showed a clear preference for relatively impacted grazing habitat components, preferring habitats in the dry season where the overall grazing utilisation had a mean rating of 3 (heavy). By definition this category includes up to 80 percent of the available biomass of the grass component. Conversely, warthog were increasingly unlikely to be found in habitats where utilisation of the grass component exceeds 80 percent (=category 4 = extreme degree of utilisation)(Odds 549 to 1, probability=0.0128) (Variable 30). Warthog showed a preference for habitats which displayed grass to forb ratios of 2,3 to 4,0 (Odds 16 to 1, probability=0.0081)(Variable 34).

Warthog demonstrated a clear affinity for habitats in which bare ground percentages were excessive (85 to 100 percent utilisation, category 4)(Odds 30 to 1, probability=0.0486) (Variable 35). Warthog were also most likely to be found in habitats where the visually dominant grass was <u>Urochloa mosambicensis</u> (Odds 134 to 1, probability=0.0012) (Variable 36).

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Warthog were most likely to be found in habitats where the visually sub-dominant woody plant species an Acacia spp. (Odds 290 to 1, probability=0.0018)(Variable 39). The warthog was 31 times more likely to be found in habitats where elephant had not killed any trees within a 40 m radius, prior to 6 months before the observation (Probability=0.0442)(Variable 41). Warthog were also most likely to occur in areas with disc pasture meter readings of 2.8 to 3.4 (Odds 904 to 1, probability=0.0068)(Variable 44).

Warthog: wet season data

CATMOD analysed the following variables but demonstrated no clear model of wet season warthog use with these variables or any of their components:

Visibility distance to animal: Variable 28, Visibility distance at animal: Variable 29, Utilisation of grasses: Variable 30, Utilisation of browse: Variable 31, Phenology of browse: Variable 33, Dominant grass: Variable 36, Sub-dominant grass: Variable 37, Dominant woody: Variable 38, Old elephant damage: Variable 41, New elephant damage: Variable 42, and Grass height: Variable 44.

CATMOD analysis established models for warthog use in the wet season and the following variables (Appendix B):

Warthog were most likely to occur at distances in excess of 100 m from

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a zone of riparian vegetation (Odds 2,041 to 1, probability=0.0464) (Variable 18), and were most likely to be sighted when ambient daytime temperatures were between 27 and 29° C (Odds 249 to 1, probability=0.0417)(Variable 23).

Warthog were most likely to occur in an area defined as open for the purposes of this study. This is an area of at least 50 m by 50 m in which the woody species had a noticeably reduced stem density in comparison to adjacent areas (Probability=0.0346)(Variable 26). Warthog displayed a clear preference for habitats where grass to forb ratios were between 0 and 1,5 (Odds 70 to 1, probability=0.0498)(Variable 34). Warthog were also most likely to occur where habitats exhibited bare ground percentages in excess of 60 percent. Optimum warthog habitat in this context appeared to be where bare ground percentages were between 60 and 80 percent (Odds 340 to 1, probability=0.0524) (Variable 35).

Warthog shows a distinct wet season preference for habitats in which the visually dominant grass species was Schmidtia pappophoroides (Odds 36,767 to 1, probability=0.0526)(Variable 36). A clear preference was also shown by warthogs for habitats in which the mean crown cover was between 6 and 16 percent (Odds 4,453 to 1, probability=0.0231) (Variable 49).

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SUMMARY

Habitat utilisation patterns: dry season

A strong similarity in dry season habitat use existed between impala, warthog and zebra. The impala, a mixed feeder, demonstrates a strong affinity for overutilised grazing areas (>80 percent of annual production). This is exactly the same situation with zebra, a grazing species. The mixed feeding warthog was similar in its preferences for overutilised area, but warthog utilises less impacted grazing areas (60 to 80 percent utilisation of annual production). Impala showed a marked tendency for areas with bare ground percentages in excess of 60 percent and zebra show a preference for areas of between 50 and 75 percent bare ground.

Impala, warthog and zebra, therefore, tended towards habitat areas where bush encroachment was likely to occur or was occurring. This was further underscored by impala and zebra preferences for areas of low crown cover. This was linked to elephant-induced mortality on the mature tree component. Warthog differed in this respect and showed a clear preference for areas of reduced browse stem densities and defined in this study as "open". Warthog use of areas dominated by _Euclea divinorum_ is a key indicator in delineating their preferred habitats.

In contrast to the preferences displayed by impala, zebra and warthog,

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blue wildebeest and Cape buffalo had a preference for grazing habitats in a less degraded state. Blue wildebeest and buffalo were most likely to utilise habitat areas with good visibility in all directions, low degrees of grass utilisation (blue wildebeest < 60, buffalo < 40 percent). Blue wildebeest and buffalo also show similar preferences for crown cover conditions, and which were higher than those of zebras and impalas. Blue wildebeest, however, prefer areas with a higher percentage of grass cover than do buffalo, impalas and zebras. Of the herbivore species considered in this study, blue wildebeest prefer areas of higher habitat quality as indicated by grass palatability and density.

The mixed feeding elephant shared characteristics of habitat use with the warthog in terms of visibility. Likewise it had an affinity for habitats in which the visually sub-dominant woody plant species are Acacia spp. Both the warthog and the elephant were most likely to utilise habitats more than 100 m from the nearest riparian vegetation. However, the warthog avoided areas of past elephant damage of mature trees, whereas and elephant show an attraction to it.

The browsing kudu and giraffe both showed an affinity for habitats in which browse is noticeably utilised. Giraffe showed the stronger correlation with heavier use in this respect. Kudu showed a preference for habitats visually dominated by Combretum apiculatum, but giraffe preferred this species when it was the visual sub-dominant. Kudu and giraffe habitat use showed a strong correlation

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with the highest mean disc pasture meter readings taken in this study. This was likely a function of the grazing component being protected by browse stem density, the increased soil moisture associated with shade, and a relative lack of grazing herbivores in the more browse dominated habitats. Kudu and giraffe also showed an aversion to all areas of elephant damage to the mature tree component. Both kudu and giraffe tended to prefer habitats with higher crown cover percentages, but the stronger correlation is with the kudu.

Habitat utilisation patterns: wet season

Impala, zebra and warthog showed a very clear common trait of preferring areas defined in this study as "open". Blue wildebeest showed no correlation with this habitat trait, but did prefer areas of enhanced visibility during this season as did warthog. Zebra and Blue wildebeest showed a close affinity with areas of higher grass utilisation, the correlation with zebra being more closely tied to over-use. Impala showed a preference for areas dominated visually by Bothriochloa radicans, zebra preferred this species when it visually sub-dominates. Impala, blue wildebeest, warthog and zebra showed a closer tie to increased crown cover percentages during the wet season than in the dry season, the highest crown cover was associated with zebra and the lowest with impala.

Warthog differed from impala, zebra and blue wildebeest in exhibiting preferences for areas with a light degree of grass utilisation, where

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the dominant grass affiliation was (Schmidtia pappophroides), and new elephant damage occurred to the tree component. Warthog also selected areas visually dominated by Grewia spp. in the wet season.

Elephant use of Klaserie habitats shows only one marked wet season affiliation, regarding Sclerocarya birrea. This is discussed in more detail in Chapter 5.

Cape buffalo showed a distinct wet season shift to areas of riparian vegetation. Like impala, zebra and blue wildebeest they had preference for areas of enhanced visibility and increased crown cover. Buffalo also prefer areas with higher veld disc pasture meter readings during the wet season.

Kudu and giraffe showed distinct temperature-related sighting correlations during the wet season. Kudu were more likely to be seen at lower ambient temperatures than were giraffe, warthogs shared this trait with kudu and giraffe being more closely aligned with giraffe than with kudu. Both giraffe and kudu contrast with the other herbivore species in this study by being found most frequently in areas of low visibility. Giraffe and kudu shared similar preferences for crown cover percentages. Wet-season giraffe use was the only non-correlation with an area defined as "open" in this study. Kudu and giraffe differed in preference of visual dominant browse species and by affiliation with areas of all elephant damage to the mature tree component. Kudu avoided all areas of elephant damage.

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DISCUSSION

Findings from this study generally concur with the literature specific to a given herbivores known habitat requirements. These are discussed below by species:

Impala

The impala is a controversial herbivore on the Klaserie Private Nature Reserve. Information from Chapter 3 suggests that the impala was not a significant herbivore factor, prior to the 1960's, on what is now the reserve. Subsequent to the 1960's, however, they have become a dominant herbivore in terms of their numerical status and consequent biomass. Aerial game count data (Figure 19) shows an impala population crash during the drought years of 1981-1983. Relatively low population levels, relative to the previous population levels, through the late 1980's, and especially those of 1981, reflect a growing awareness on the part of the management staff that the impala may pose a major problem relating to proper veld management of the Klaserie Private Nature Reserve. This is underscored by data from this study, work done by Zambatis (1982,1983, 1985), and particularly studies done by the erstwhile Transvaal Chief Directorate of Nature and Environmental Conservation on the Klaserie Private Nature Reserve

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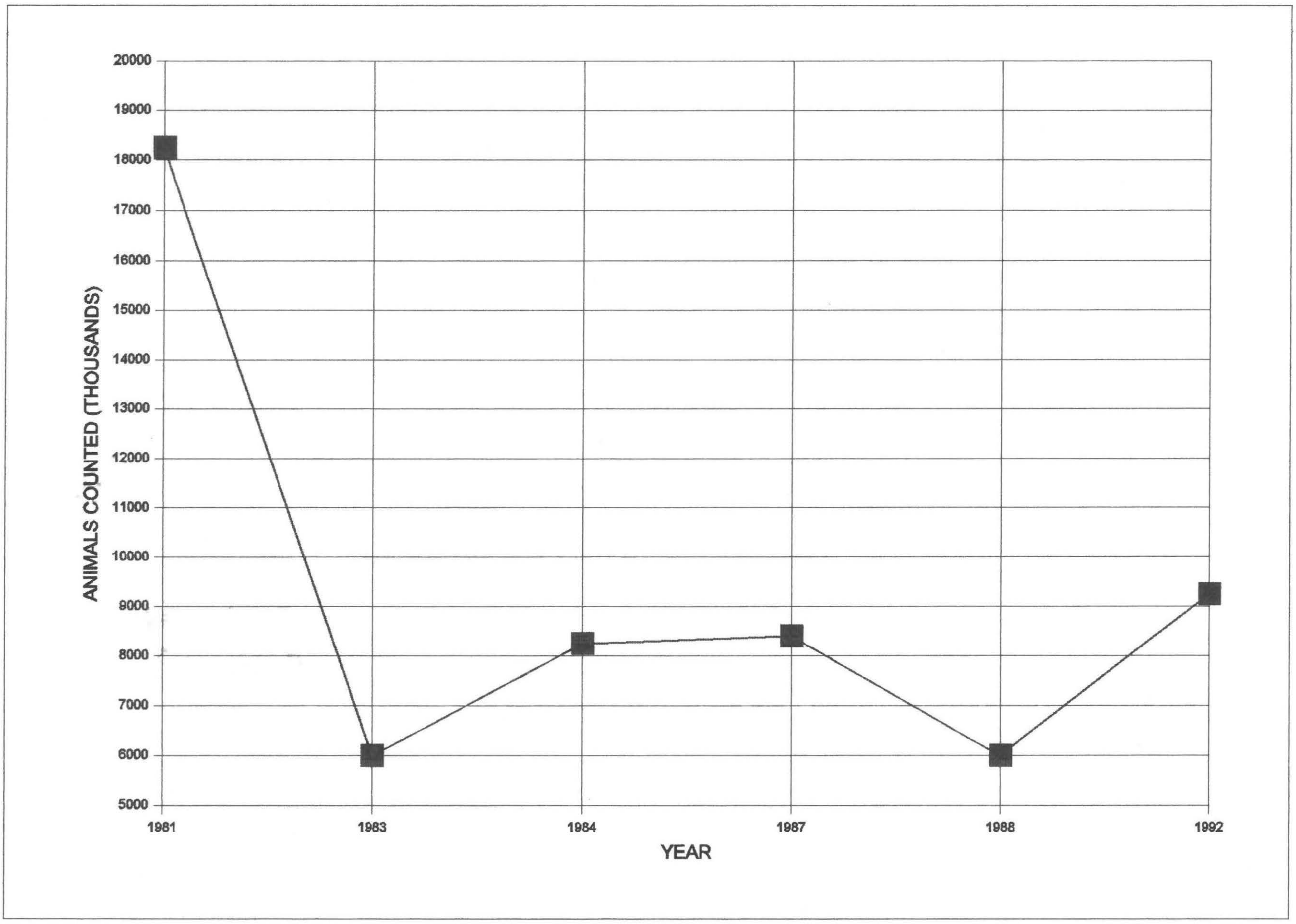

Figure 19: Impala population trends, Klaserie Private Nature Reserve, 1981-1992 non-inclusive (Data are not available for 1982, 1985, 1986, 1989, 1990, or 1991. Source: Aerial game count data, Klaserie Private Nature Reserve, Northern Transvaal (Annual report).

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(De Villiers *et al*. 1989). Substantial efforts to initiate a sustainable culling programme, both through commercial harvest and a liberal system of permits to reserve owners, of impala have undoubtedly helped to keep their numbers at levels below that to which they would naturally be expected to rebound under current habitat and predator conditions (Sinclair 1985).

Nevertheless, the demands by Klaserie Private Nature Reserve owners for biltong (meat) hunting probably tend to dampen these efforts to some degree (Leibnitz , pers. comm.*). Impala, on the Klaserie, are currently utilised for sport and biltong hunting, staff rations and commercial culling for revenue.

Impala have shown preferential use of habitats in studies conducted near the Klaserie Private Nature Reserve (Pienaar 1974) and are noted for their ability to successfully survive in degraded habitats even during periods of stress. Pienaar (1974) also noted that impala are able to rapidly switch from a grazing to a browsing diet, and, further, impala do well in areas of bush encroachment which leads to a "diminution of competitive influence of other herbivore species". This concurs with findings by De Villiers (1989) and in the current study, that impala utilise degraded habitats on the Klaserie Private

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Nature Reserve, probably to the detriment of other herbivores. The CATMOD confirmation of impala use of degraded areas, particularly high utilisation of the grass component, grass to forb ratio, and bare ground percentages was particularly revealing in this regard (Pettifer and Stumpf 1981). Further, impala demonstrated a clear affinity for areas of elephant damage to the mature tree component, a factor in bush encroachment. Impala preference for areas of low tree canopy cover also points to bush encroached habitat utilisation. This fits with observations by Munro (1980) and McNaughton and Georgiades (1986). Studies on impala diets by Stewart (1971) Rodgers (1976) and Owen-Smith and Cooper (1985) point further in this direction and link impala as an indicator of degraded habitats. Optimum impala habitat, as indicated in the current study, generally exhibited traits most commonly associated with poor grazing components and bush encroachment indicators (Scholes 1987, Tainton et. al. 1980, Walker 1980, Trollope et. al. 1990). Impala demonstrated no affinity with a given habitat type on the Klaserie Private Nature Reserve.

Zebra

The zebra is an exclusive grazer with bulk feeding traits (Ngethe 1976) and it is known to show seasonal and monthly dietary variations in habitats similar to those of the Klaserie Private Nature Reserve (Ben-Shahar 1990). This trait was also demonstrated by Lamprey (1963) and Eltringham (1979) who showed ecological separation between zebras and close-grazing associates such as the blue wildebeest. This

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principle of separation was also more recently demonstrated in the Kruger National Park by Wentzel, Bothma and Van Rooyen (1991). Zebra populations on the Klaserie Private Nature Reserve suffered severely during the drought years of 1981 to 1983 and again in 1988 (Figure 17 and Table 7) but their populations showed a tendency to rebound rapidly. Zebra are utilised on the Klaserie Private Nature Reserve for sport hunting, biltong hunting by owners and for staff rations. Zebra in this study exhibited a habitat preference for areas of the reserve with an enhanced visibility, high degrees of grazing utilisation, high percentages of bare ground and low percentages of canopy cover. Further, zebra on the Klaserie showed a tendency to shift their habitat preference to areas of higher canopy cover during the wet season, when temperatures are higher, which concurs with findings by Kutilek (1979) and Penzhorn (1982).

Zebra use of habitats on the Klaserie Private Nature Reserve appears to be, in part, opportunistic as the "classical" habitat components usually associated with zebra are not present (Talbot and Talbot 1963, Gwynne and Bell 1968, Bell 1971). On the Klaserie zebra utilize grazing habitat components which are dominated by "Increaser" species such as _Bothriochloa_ _radicans_ which are not indicative of optimum zebra habitat as expressed in the literature (Tainton _et_. _al_. 1980, Trollope _et_. _al_. 1989). The zebra's bulk feeding tendencies concur with it being found in areas with disc pasture meter readings of between 2,8 and 4,0. Zebra use of habitat components on the Klaserie described as "open" in this study, further points to the selection of

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available habitat components more reflective of the "classic" definition (Open savannah). As was noted in Chapter 3, such areas were limited on the Klaserie Private Nature Reserve. Optimum zebra habitat on the Klaserie appears to be in those grazing types exhibiting a degraded grazing component and generally confined to habitat types 10 (*Acacia nigrescens*-*Grewia* spp.), 11a (South Western Mixed Woodlands) and 13 (*Combretum apiculatum*-*Sclerocarya birrea*, *Grewia* spp. Short Woodland-Southern Extension) these findings concur closely with those of Zambatis (1985).

Blue Wildebeest

Blue wildebeest are generally known to favour open grasslands (Spinage 1986). Such habitats are limited on the Klaserie Private Nature Reserve. It can be expected, therefore, that those habitats exhibiting semi-open to open grassland characteristics would be selected for by blue wildebeest (Talbot and Talbot 1963). On the Klaserie, the blue wildebeest populations there crashed after the drought of 1981-1983 (Figure 17 and Table 7), further emphasising their close relationship with the grazing component of the habitat and its sensitivity to drought and overgrazing. Subsequent, blue wildebeest population recovery (Figure 17) has been steady but slow. Witkowski (1983) documented an "unusually high" density of blue wildebeest on the Klaserie Private Nature Reserve prior to the drought (1981) and postulated its likely adverse impact on the grazing habitat.

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The previously noted ecological separation, in the current study, with zebra is confirmed by the selection of habitat areas by wildebeest which show a preference for lower grazing impacts particularly in the area of the utilisation of the available grass. This would confirm findings by Field (1968b, 1970) and Grunow (1980). On the Klaserie wildebeest also preferred areas of lower bare ground percentages, than did zebra, and they were not shown by CATMOD to have an affinity for areas dominated by "Increaser" grass species. Wildebeest differed notably from zebra on the Klaserie by selecting habitat areas with a higher canopy cover during both the wet and dry seasons. Wildebeest share with zebra a preference for areas of a more "open" nature. Like the zebra, optimum wildebeest habitats on the Klaserie generally are found in habitat types 10 (Acacia nigrescens-Grewia spp.), 11a (South Western Mixed Woodlands) and 13 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Southern Extension). It is clear, however, that the wildebeest utilize different areas of these types than do the zebra (Field 1968a).

Cape Buffalo

The Cape buffalo is known to have been relatively scarce on what is now the Klaserie Private Nature Reserve prior to its inception in 1972 (Crookes* and Gillatt, pers. comm. **). Buffalo numbers increased

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**: Mr. I.F.G. Gillatt, P.O. Box 935, Stanger 4450

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rapidly after reserve's inception, only to crash during the 1983 drought (Figure 17 and Table 7). Buffalo numbers during the course of this study approximated 800 animals (Table 7). Buffalo are known to inhabit relatively fixed home ranges in areas of the Kruger National Park, but to exhibit wide variations in respect of the seasonal changes in the vegetation, which causes considerable home range overlap in different herds (Smuts 1974, Mason 1986). This home range trait in the buffalo can make a scientific culling programme difficult. Trophy buffalo hunting is an important source of revenue for the Klaserie Private Nature Reserve.

Sport hunting is an important facet of buffalo management, as the buffalo is highly sought after as a member of the "big five" (lion, leopard, elephant, buffalo and rhinoceros. A limited number of permits for trophy, male, animals are put out annually, on bid, to safari operators. Additionally, a limited permits for both sexes of buffalo are also allowed to reserve owners (Leibnitz, pers. comm. *).

The buffalo is a primary grazer and is known to be stressed by crude protein inadequacies during the dry season (Eltringham 1979). Buffalo are known to show a significant difference in their habitat use, relative to its vegetative composition, when compared to impala, warthog and blue wildebeest in areas near to the Klaserie Private

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Nature Reserve (Wentzel Bothma and Van Rooyen 1991). Use of habitats on the Klaserie by buffalo monitored in the course of this study proved to be relatively inconclusive when subjected to CATMOD analysis. The CATMOD model proved to be small and showed little conclusively. Buffalo did show a predictable affinity for areas of light grazing pressure even during the dry season. Buffalo also showed a preference for areas of higher canopy cover during the warmer months. There is little revealing in this as it confirms the findings in the body of the literature (e.g.; Pienaar 1969).

Optimum Cape buffalo habitat was not readily identified from the data produced in this study. This is likely a result of the herd structure of buffalo populations which results in few observations with large numbers of animals (Sinclair 1974). Each observation, then, may number in the hundreds of animals, but yield only one observation plot. The lack of a conclusive model may also be a function of a general lack of selectivity on the part of buffalo in Klaserie habitats (Dunbar 1978).

Elephant

Elephants are discussed in detail in Chapter 5 relative to their ability to impact on the habitat, specifically on the mature tree component. The data presented here are, however, oriented toward non-destructive habitat utilisation and preferences. The data presented in Chapter 5 were collected in conjunction with all herbivore

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sightings and relates to the elephants impacts on Klaserie Private Nature Reserve. The data in this Chapter were collected specific to actual elephant presence only and relates to elephant utilisation of habitats primarily in a non-destructive capacity. The data produced for destructive behaviour in elephant proved to be highly conclusive and is discussed fully in Chapter 5.

Although the CATMOD model for elephant was small it yielded some specific predictors for elephant habitat on the Klaserie Private Nature Reserve. Elephants showed a definite affinity for habitats dominated by Acacia Spp. during the dry season. Conversely they showed a distinct preference for wet season habitats sub-dominated by Sclerocarya birrea, this preference mirrors findings by Coetzee (1979). Further, elephants showed a preference for areas of increased canopy cover. Optimum elephant habitats on the Klaserie Private Nature appears to be those areas dominated by mature trees, particularly Acacia spp. and Sclerocarya birrea.

Kudu

Kudu are known to exhibit seasonal variations in habitat utilisation in southern Africa (Simpson 1972). Such use patterns are confirmed by Hirst (1975) in lowveld habitats near the Klaserie Private Nature Reserve. Hirst (1975) documents a near lack of selectivity in lowveld habitats at low kudu population densities and subsequent difficulty in obtaining adequate samples. Kudu populations on the Klaserie

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Private Nature Reserve have shown a clear reaction due to drought (Figure 17 and Table 7) but have remained relatively constant on the study area over the entire decade. The Klaserie kudu population has consistently remained below 1 000 individuals and has been subject to a limited amount of sport hunting on a sustained basis. The kudu population at the end of this study was estimated to be 619 (Table 7).

Kudu on the Klaserie Private Nature Reserve appear to exhibit habitat utilisation patterns predicted from the body of literature. Kudu prefer areas of denser bush as typified along riparian zones (Conybeare 1975). The kudu on the Klaserie exhibit this trait by preferring habitats with limited visibility, thus demonstrating thick bush situations, they also prefer areas exhibiting noticeable browse utilisation. The obvious browse utilisation contrasts with the situation on most of the reserve. The kudu affinity for areas of noticeable browse utilisation concurs with findings by Owen-Smith (1979). Kudu on the Klaserie are noticeably linked with Combretum apiculatum during the dry season, by interpretation this would link them with the riparian areas in Combretum apiculatum dominated sites. Kudu observations were noticeably fewer in Colophospermum mopane types (Owen-Smith and Cooper 1987b).

Kudu demonstrated a distinct aversion to areas of elephant damage to the mature tree component, this is in contrast to their preference for higher canopy cover habitat areas. By extrapolation it is probable that the tree components in preferred kudu habitat differ

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from those in preferred elephant habitat. On the Klaserie Private Nature Reserve, kudu are a negative indicator of preferred elephant habitat. Optimum kudu habitat in the context of the Klaserie Private Nature Reserve are dense areas of bush, probably of riparian influence, occurring in Combretum apiculatum habitat types.

Giraffe

The giraffe is a primary browser with few deviations in its diet (Hall-Martin 1974). The presence of giraffe in sustainable numbers over time is, therefore, a reliable indicator of the viability of the browse component of a given habitat (Pellew 1984) . On the Klaserie Private Nature Reserve giraffe numbers remained relatively constant over the period of 1975-1981 (Witkowski 1983). These numbers dipped following the drought year of 1983 and began to increase again throughout the middle of the decade before falling again in 1988 and 1989, also due to drought (Figure 17).

Giraffe numbers on the Klaserie Private Nature reserve appear to be held in check primarily by culling them for staff rations and by mortality primarily associated with lions (Leibnitz, pers. comm.*). The noted shift to giraffe as a staple in Klaserie ration shooting over the past three decades is a likely indicator of broad-scale

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habitat changes on the Klaserie Private Nature Reserve (Chapter 3). Giraffe habitat selection on the Klaserie concurs with the body of literature on the topic (e.g.; Oates 1972, Simpson 1972, Sauer et. al. 1977, Pellew 1984).

CATMOD analysis of giraffe use in this study shows a preference for more open browse-dominated habitats where the primary browse species is Combretum apiculatum or Acacia spp., such a description encompasses the bulk of the reserve. In general giraffe, like kudu, showed a preference for increasingly higher levels of browse utilisation. Confirmation of the browse oriented nature of giraffe habitats is demonstrated by the association of giraffe use with Panicum maximum as a visual sub-dominant. Panicum maximum is a "decreaser" grazing species and would not be expected to be a sub-dominant grass species in habitats used heavily by grazing herbivores (Trollope et. al. 1990). Further, giraffe show a preference for habitats with high disc pasture meter readings, a second confirmation of low grazing impacts in preferred giraffe habitats. Giraffe on the Klaserie, then, tend to show an ecological separation from grazing herbivores as expected.

No height class data were gathered in the current study and it is not possible to glean such from the giraffe preference for higher canopy cover, however the impression gained during the course of the study is that giraffe on the Klaserie preferred habitats dominated by woody species that lacked mature over-story growth forms. Giraffe appeared

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to optimally prefer those areas which actively indicated both bush encroachment and, hence, high levels of browse availability.

Warthog

The warthog is a ubiquitous herbivore in the Klaserie Private Nature Reserve. Warthog distribution must be assumed to be based on preferential utilisation of habitats to a higher degree than most herbivores, other than impala and elephant, as they are virtually uninhibited by fences. Warthog are known to favour open bushveld, grasslands, vleis and short grass flood plains (Bothma and Van Rooyen 1989, Wentzel et. al. 1991). Under stress of drought warthog suffer high mortality rates. The warthog population of the Klaserie Private Nature Reserve decreased substantially between 1981 and 1983 during that drought (Schneebeli 1983). Warthog were estimated at 984 during this study (Table 7), and appeared to be well distributed throughout the reserve, but particularly in the southern half. Warthog sightings, in contrast with buffalo, yielded numerous plots and low animal counts per sighting. The warthog data base is therefore statistically significant and yielded a definitive model under CATMOD analysis.

Warthog on the Klaserie Private Nature Reserve show some clearly defined habitat preferences. In particular, warthog prefer areas defined in this study as "open" of the herbivores included in this study warthog had the strongest correlation with this variable.

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Enhanced visibility was always an indicator of preferred warthog habitats. Secondly warthog showed a distinct preference for heavily impacted grazing areas, including high utilisation categories and high percentages of bare ground. Low grass to forb ratio's were also an indicator of warthog habitats on the Klaserie.

Key vegetation components of optimum warthog habitat, on the Klaserie Private Nature Reserve were Euclea divinorum and Acacia spp. as woody species and Eurchloa mosambicensis as a grass species. Warthog appear to be an indicator of over-utilised grazing habitats on the Klaserie.

CONCLUSIONS

The validity of the use of CATMOD in this manner is verified by the previously cited consultations (Groeneveld and Van Der Linde), and by the strong correlations shown with otherwise expected outcomes based on known habitat preferences of the subject herbivores. These were illustrated in the previous section.

Emphasis for further herbivore studies in habitats on or similar to those of the Klaserie Private Nature Reserve may do well to focus on the habitat variables which were selected by CATMOD as being important from the much larger list of data collected during the course of this study (Table 8). Out of the 55 variables for which data were collected during the course of this study less than half (10 to 20 depending on species and season, as identified in Appendix B, were

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identified by CATMOD, with this application, as being important relative to the subject herbivores and habitats of the Klaserie Private Nature Reserve.

CATMOD analysis has indicated some clear habitat affinities, by species, and by season of use. These are strong indicators of key areas of herbivore habitat use highlighting important elements on the Habitat of the Klaserie Private Nature Reserve. The management implications of these elements will be discussed fully in Chapters 6 and 7.

What does emerge clearly, here, is an increasing pressure by grazing and mixed feeding herbivores on a relatively small area of the Klaserie Private Nature Reserve as noted in Chapter 3 and confirmed in this Chapter by CATMOD analysis of herbivore selection of those elements which are having negative use influence, specifically in habitat types 10: Acacia nigrescens-Grewia spp., 11a: South Western Mixed Woodlands, 11b: South Eastern Mixed Woodlands, 12: Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodlands with Open Woodland Intrusions, 13: Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Southern Extension. The selection of these elements by herbivores has implications to the qualitative and quantitative elements of the vegetative component. This selection by grazing herbivores verifies the probability of negative habitat impacts to the grazing types over time, with an increased likelihood of soil erosion and bush encroachment. Subsequent, negative, impacts

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to the grazing herbivores are likely as their carrying capacity is further reduced and the nutrition levels are lowered through the elimination of the more palatable species.

Data presented in this chapter and in Chapter 3 and confirmed by CATMOD analysis for the heavily selected browsing herbivores as key use elements are expected to have impacts in the key browsing types, specifically habitat types 2: Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Western Extension) and 4: Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland with Sclerocarya birrea intrusions), which emerge as the key habitats for the browsing species.

Conclusions by herbivore species with habitat implications are:

Impala

Impala demonstrated habitat selection traits which put them at odds with the grazing herbivores of the Klaserie Private Nature Reserve. Impala's ability to utilize degraded habitats at the expense of grazing herbivores appeared to be giving them a competitive advantage as demonstrated by their biomass on the Klaserie Private Nature Reserve and their selection for habitat parameters where they had a competitive edge due to their mixed feeding ability. In this study impala habitat selection traits put them directly in competition with warthog and zebra in particular. The preference by impala for

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overgrazed areas within the identified grazing types of the Klaserie Private Nature Reserve makes them a prime candidate for the further degradation of such areas and a force in further bush encroachment on the reserve. The impala's preference for habitat areas with high bare ground readings also causes them to be suspect in causing soil erosion. The selection of habitats, by impala, with elephant-induced tree mortalities at all times of the year further places them in areas where bush encroachment is an on-going process.

Zebra

Zebra appeared to be occupying habitat areas where the grazing component is in a degraded state. It is probable that zebra continue to do well on the Klaserie Private Nature Reserve because of their bulk feeding abilities. Zebra response to past drought on the reserve, however, shows them to be vulnerable within the habits on the reserve. Zebra habitat selection mirrored that of impala in many ways, particularly in their selection of areas where bare ground percentages were high and where elephant-induced tree mortalities were present. The selection by zebra of habitats dominated by *Urchloa mosambicensis* points further in the direction of degraded habitat preferences.

Blue wildebeest

Blue wildebeest, like zebra and impala selected areas within the

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previously described grazing types that exhibited degraded conditions. Unlike zebra and impala, however, they selected areas within these types which are less impacted in regard to the grazing component during the dry season. This preference, by wildebeest, for areas of higher quality habitat is further highlighted by a preference for areas of increased canopy cover, indicative of an intact mature tree component. The preference which wildebeest showed for more impacted grazing areas during the wet season is likely a selection for succulent growth after the rains.

Cape buffalo

Cape buffalo data in this study are inconclusive, other than to show a correlation with high quality grazing areas. Of the grazing species considered in this study, buffalo demonstrated a preference for the highest quality components as indicated by their preference for areas of low bare ground percentages, and high disc pasture meter readings. Buffalo preference for grazing habitats near to zones of riparian vegetation influence is another strong correlation linking buffalo to less degraded grazing habitat areas. Buffalo seemed to show an ecological separation from the blue wildebeest, warthog and zebra. Undoubtedly the large home ranges utilised by buffalo and the movement of their herds over large areas was reflected in these data.

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Elephant

Elephants are more completely discussed in Chapter 5. However, elements of the CATMOD analysis of their habitat use patterns which are relative to this Chapter need mentioning. Elephants share with Cape buffalo an affinity for zones of riparian influence. Elephant were indicators of habitats dominated by mature tree components, specifically Acacia nigrescens and Sclerocarya caffra and with a dense canopy cover percentage.

Kudu

Kudu utilisation of Klaserie Private Nature Reserve habitats was tied closely to zones of dense bush with limited visibility and high browse utilisation. Kudu are a negative indicator of areas preferred by elephant when damaging mature trees. Preferred kudu habitat was noticeably more dense than surrounding areas of browse habitat. It is feasible that the fence which surrounded the Klaserie Private Nature Reserve during this study may have had a concentrating influence on the enclosed kudu in that kudu prefer to browse where tannin levels are low. Higher browse utilisation is generally an indicator of higher tannin levels. Conversely kudu were associated with low levels of grazing pressure. The higher browse utilisation associated with kudu on the Klaserie, in contrast to most of the reserve, likely indicated the highly preferred kudu habitat areas.

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Giraffe

Like the kudu, giraffe were associated with higher levels of browse utilisation. Giraffe differ substantially with kudu in that they preferred more open bush areas. Giraffe also differed from kudu in that they did not avoid areas of elephant inflicted damage on the mature tree component. Like kudu, giraffe were an indicator of low grazing impacts, with high quality grasses and low grazing impacts as indicated by disc pasture meter readings.

Warthog

Warthogs shared with zebra and impala a preference for degraded areas within the Klaserie Private Nature Reserve's grazing habitat types. Like the giraffe they were tied to areas described as "open" and to higher levels of overall visibility. Warthog preferred areas of higher bare ground percentages, "increaser" grass species and forb percentages. Warthogs were an indicator of poor grazing conditions and actively avoided areas of dense bush.

The analysis of herbivore use by CATMOD confirms the conclusions regarding habitat impacts outlined in Chapter 3. Unless aggressive habitat improvements and alterations are instituted, it is reasonable to expect further degradation of the grazing component of the reserve and its consequent ability to support additional herbivores.

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CHAPTER FIVE: ELEPHANT-HABITAT INTERACTIONS

INTRODUCTION

During the course of the annual monitoring of game numbers, by management and the erstwhile Transvaal Directorate of Nature and Environmental Conservation on the Klaserie Private Nature Reserve in 1989 and 1990, it became apparent that an aberration in elephant numbers was occurring (Figure 20). The occurrence of an apparent irruption immediately prior to the inception of this study provided an opportunity for additional, elephant specific, data to be collected. Consequently, data specific to elephant inflicted mortality on the tree component was incorporated in this study from its onset. This was undertaken at the request of Klaserie Private Nature Reserve Warden, Erwin P. Leibnitz.

Causative factors for the elephant irruption, which resulted from the observed immigration of animals from adjacent areas of the Kruger National Park, are the topic of some speculation, the most likely reason being culling of elephant populations in the Kruger National Park during 1988 and 1989. Another possibility could be density differences of the mature tree components in the Kruger National Park, adjacent to the Klaserie Private Nature Reserve in 1989/1990. Certainly the work of Wing and Buss (1970) suggests such a potential. Wheelock (1980) also suggests shade as an elephant attractant, a factor which would be influenced when trees are killed by elephants.

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The knowledge of elephant ecology and their habitat interactions, uses and needs, specific to the Klaserie Private Nature Reserve, are limited and relatively new. Recent trends in elephant populations and subsequent habitat impacts, both actual and perceived, raised important questions relative to the proper management of elephants within the scope of Klaserie Private Nature Reserve habitats. Coincidental with the documented rise in numbers, elephant damage complaints by members of the Klaserie Private Nature Reserve began to escalate in 1988-89 (Nel, pers. comm.* and Connan, pers. comm.**). This resulted in the installation of electrified perimeter fences around many of the member's camps in an effort to stem the damage and mortality to the large, mature trees at the camp sites. These trees flourish around many of the camps due to localised husbandry practices, and the deliberate location of many camps among such trees for aesthetic purposes. It was the increasing elephant-inflicted mortality on these trees which initially defined the possibility of a an elephant-induced management problem in this regard.

The Klaserie Private Nature Reserve encompasses the known, historic, elephant range in the lowveld (Smith 1985, Van Rooyen & Theron 1989, Ebedes, Vernon & Grundlingh 1991). In the current century elephants occurred sporadically and were uncommon in the Klaserie area through the 1940's. Probably due to hunting pressure.

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The first recorded hunting specimen in the area was taken in 1947 (Gillatt, pers. comm.*), after which elephant numbers remained quite low through the 1960's but began to increase in the early 1970's to about 150 individuals.

After the inception of the area into the Klaserie Private Nature Reserve annual counts of elephants began. This provided an excellent elephant number monitoring process. Elephant numbers in the Klaserie Private Nature Reserve held steady throughout the 1970's and into the early 1980's (Figure 20). Elephant numbers then declined during the middle 1980's before increasing significantly in 1989 to an estimated peak of 400 animals in 1990 before declining slightly, again, in 1991. During this period the real elephant densities on the Klaserie reached 10,5 animals per 2 000 ha as opposed to 7,0 animals per 2 000 ha in the adjacent Kruger National Park (Nel 1991). In 1992 elephant densities on the Klaserie were still higher than in the Kruger National Park. De Villiers (1992) suggested that a sustainable stocking rate of about 1 elephant per 2 km^2 on the Klaserie Private Nature Reserve.

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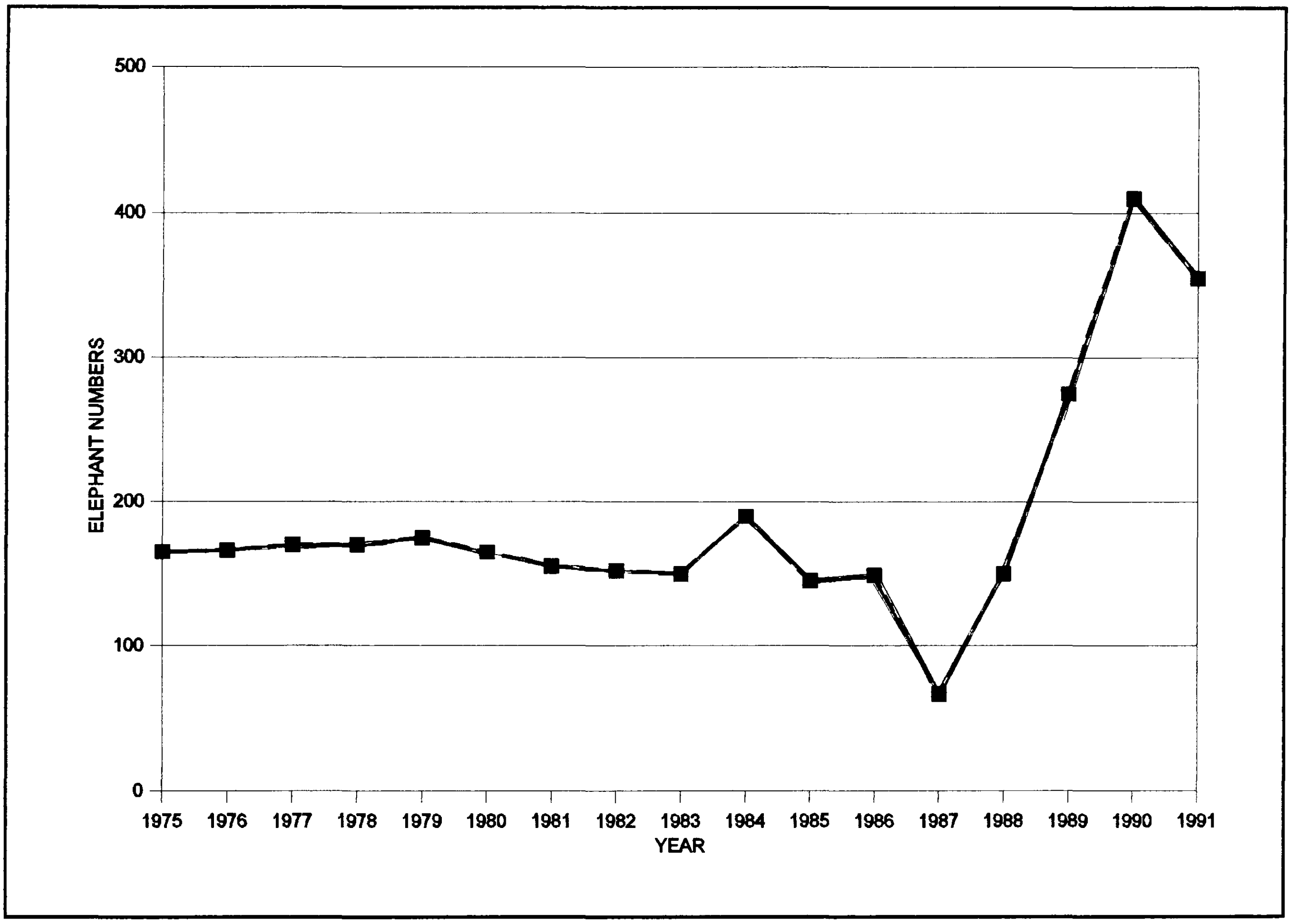

Figure 20: Elephant counts figures 1975-1991 in the Klaserie Private Nature Reserve, Northern Transvaal. Source: Klaserie Private Nature Reserve, and erstwhile Transvaal Directorate of Nature and Environmental Conservation.

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METHODS

Data specific to elephant-inflicted tree mortality were collected in association with each plot used in other herbivore studies (Table 3) as described in Chapter 3. Trees were defined as being at least 85 mm in diameter at breast height, or that point on the trunk at 1,23 m above the ground level (United States Department of Agriculture, Forest Service 1973). This provision was designed to eliminate woody species, or individuals, which had either not yet attained, or were inherently incapable of developing an overstory configuration. Tree mortality data were recorded in each plot where it occurred at a distance no greater than 20 m from the centre of the main plot. Each data set collected, therefore, encompassed a plot of 40 x 40 m in diameter.

Tree mortalities were classified in one of two categories 1=new 2= old. New mortalities were considered those that had occurred ≤ 6 months prior to the plot reading. Old mortalities were those of > 6 months to about 15 years. Old tree mortalities were not counted unless clear evidence was still visible implicating elephants. Dead standing trees with no bark, for example, were not counted as it could not be ascertained as to the causative factor in their mortality. Differentiation between old and new damage was based on a known occurrence, such as a tree observed to have been pushed over during the study period, retention of leaves, stem moisture or adherence of bark to the trunk. Stem moisture retention, particularly, was often

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a key factor. While such differentiation can be highly subjective in more arid areas (Viljoen 1989) it was deemed feasible in this relatively humid climate. Specifically, this study focused on new tree mortalities occurring between November, 1989 and February 1992. The reason for this was to gauge what damage was actually occurring because of the elephant irruption. The period of six months was arrived at to coincide with the approximate time of population increase (Figure 20).

RESULTS

The results are presented in Figures 21-25. Elephants were shown to have had a significant impact on the tree component of the reserve , but it was most concentrated on *Combretum apiculatum*, *Sclerocarya birrea*, *Acacia nigrescens*, and *Colophospermum mopane* (Figure 21). This was particularly true in the new mortality category (Figure 22). The new mortality corresponded exactly with the sharp rise in elephant numbers immediately prior to and during the course of the study. As a percentage of the tree component, this effect was particularly pronounced on two species: *Sclerocarya birrea* and *Acacia nigrescens* (Figure 21). This is in accord with data suggesting preference in elephants diets for selected woody species (Coetzee 1979, Viljoen 1989). The suggestion of destructive use of habitats by elephant is not unprecedented (Wing & Buss 1970, Viljoen 1991), and corresponds with data collected by (Eltringham 1979).

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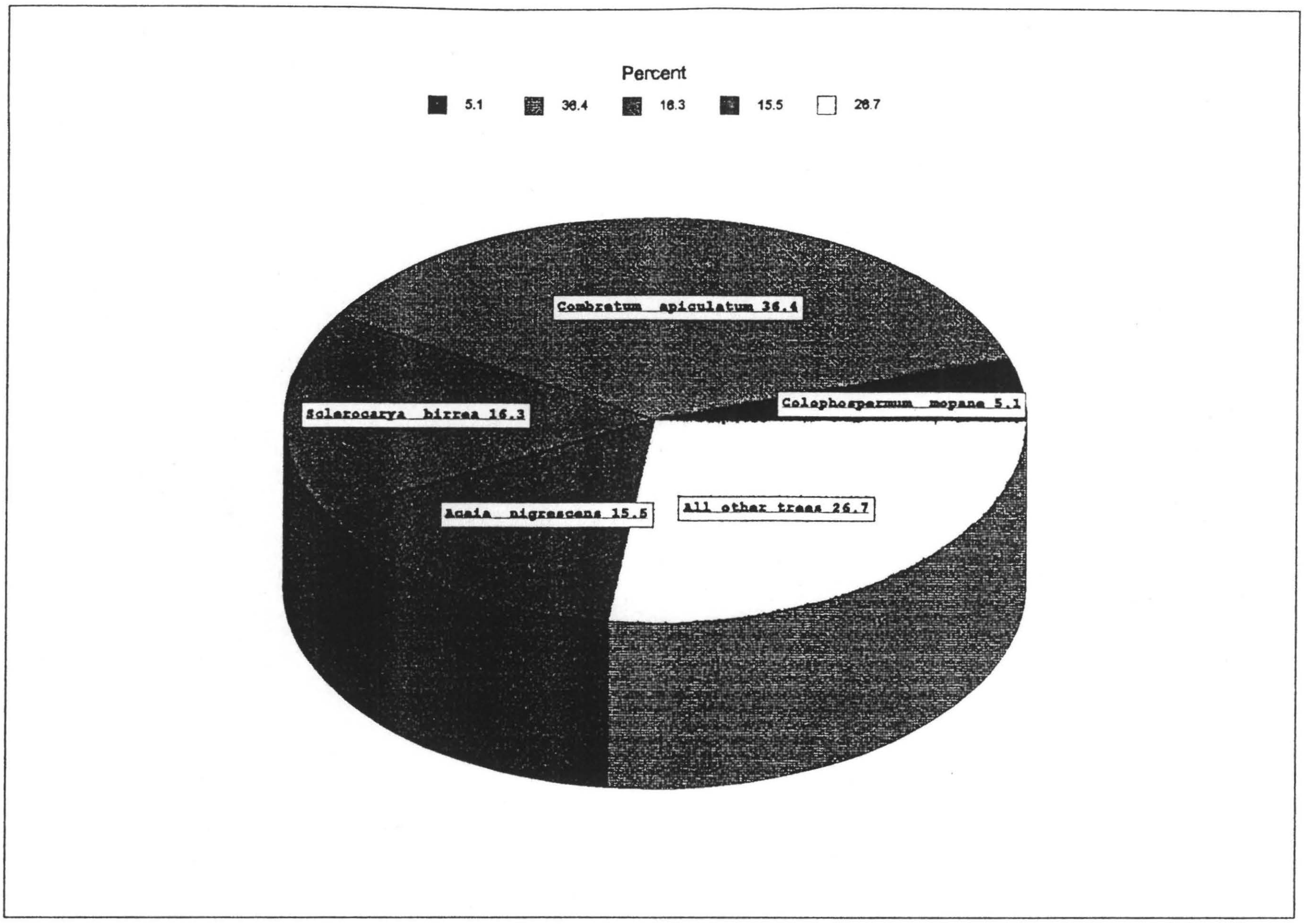

Figure 21: Percentage of elephant induced mortality by tree species on the Klaserie Private Nature Reserve, Northern Transvaal. Showing total mortality including new and old categories for all Klaserie Private Nature Reserve Habitat types. Data collected 1990-1992 based on 120 observations.

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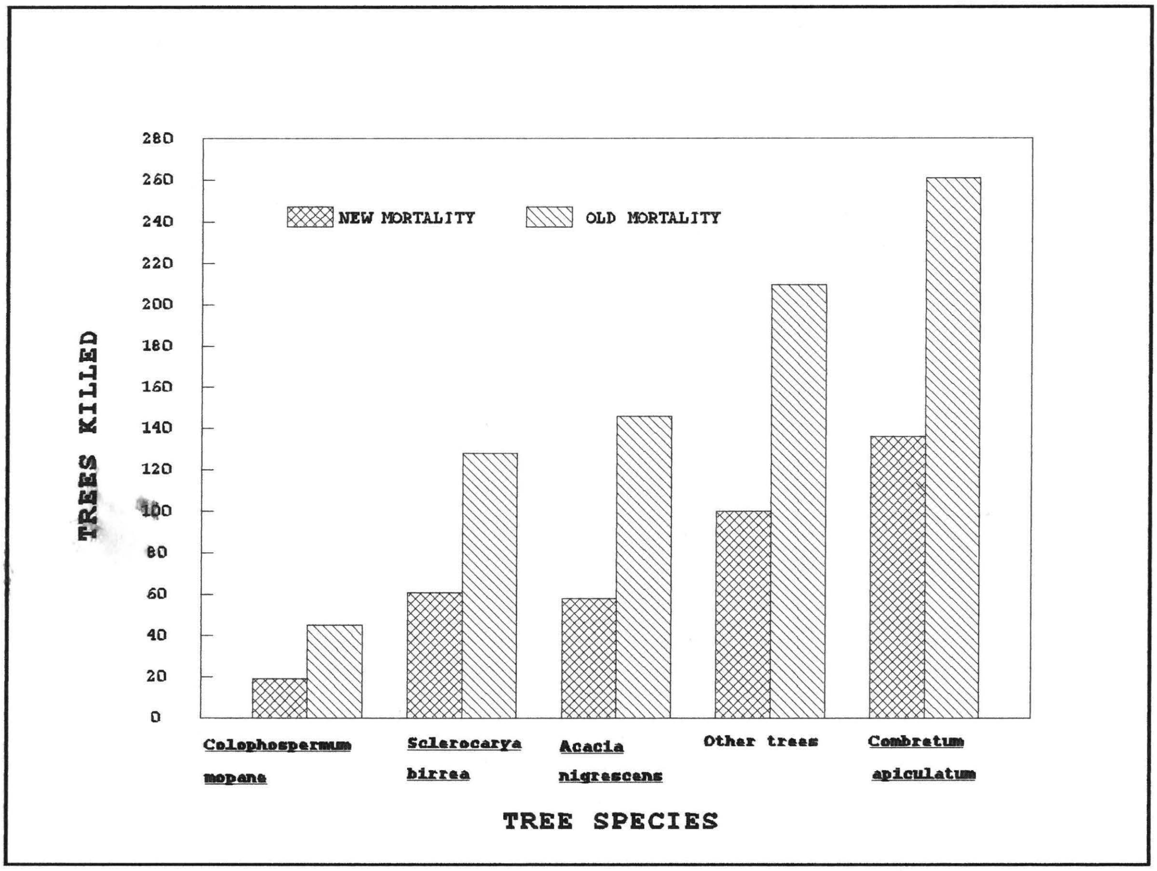

Figure 22: Elephant-induced mortality by major tree species, contrasting old and new damage. New mortality is defined as having occurred ≤ six months prior to data collection and old mortality > six months to about 15 years prior to data collection (1990-1992) based on 120 observations in all habitat types. Klaserie Private Nature Reserve, Northern Transvaal.

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Mortality on Combretum apiculatum in this study, was clearly the highest of any one species on a percentage basis (Figure 21). This corresponded with the dominance of Combretum apiculatum throughout virtually the entire Klaserie Private Nature Reserve, estimated by De Villiers et. al. (1992) at densities of 146,34 Trees/ha. Colophospermum mopane also exhibited localized elephant damage proportional to its preponderance of occurrence in some habitat types (Table 10). In contrast Acacia nigrescens was estimated at a mean of 36,3 trees/ha. and Sclerocarya birrea at only 6,5 trees/ha for the entire Klaserie Private Nature Reserve (De Villiers 1992).

New tree mortality (Figure 22) was approximately half that of the old ones for all tree species. Allowing for the fact that dead trees on the Klaserie Private Nature Reserve exhibited substantial retention in the rooted state, this seems to show a significant increase in the occurrence of elephant-induced damage relative to the mature tree component. Admittedly, the methodology for determining old damage was somewhat subjective. However, it was performed deliberately in a conservative manner to avoid confusing insect, disease or lightning-caused mortality from being included. Judgement errors, therefore, would have led to an underestimation of tree mortality figures, rather than an overestimation because of this deliberately conservative approach.

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Table 10: Average number of live trees per hectare, all age classes, by habitat type on The Klaserie Private Nature Reserve, with emphasis on the species selected for and indicative of elephant-induced tree mortality. After De Villiers *et. al*. (1992). (See also Table 11)

HABITAT TYPE	*Combretum apiculatum*	*Acacia nigrescens*	*Sclerocarya birrea*	*Colophospermum mopane*
1	54,5	35,5	9,5	<1,0
2	79,1	33,4	8,6	<1,0
3	3,8	<1,0	3,8	166,7
4	64,4	22,7	11,4	<1,0
5	No data	No data	No data	No data
6	37,9	11,4	1,9	<1,0
7	34,7	6,3	18,9	47,3
8	119,9	25,3	3,2	<1,0
9	No data	No data	No data	No data
10	3,8	20,8	3,8	<1,0
11a	15,5	13,8	6,9	<1,0
11b	34,7	18,9	<1,0	<1,0
12	No data	No data	No data	No data
13	No data	No data	No data	No data
Mean	44,2	36,3	6,5	101,6

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When the data are considered by habitat type it is quite clear that a significant new impact by elephants on the mature tree component occurred during the study period. Given the low elephant population densities documented for most of this century, it is likely that the proportional damage illustrated in Figure 22 is accurate.

Analysis of tree mortalities by habitat type indicates a strong affinity for Klaserie Private Nature Reserve types 2 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Western Extension), 4 (Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland with Sclerocarya birrea intrusions). and 10 (Acacia nigrescens-Grewia spp.) (Figure 23). Further analysis shows this mortality to be disproportionately skewed towards Sclerocarya birrea and Acacia nigrescens when the density of each species on a per hectare basis is considered (Table 10). When focusing on these two tree species and utilising data from De Villiers (1992) for mean tree densities, then Sclerocarya birrea is nearly 5 times as likely to suffer mortality by elephants on all habitat types in the Klaserie Private Nature Reserve than Acacia nigrescens (Figure 24).

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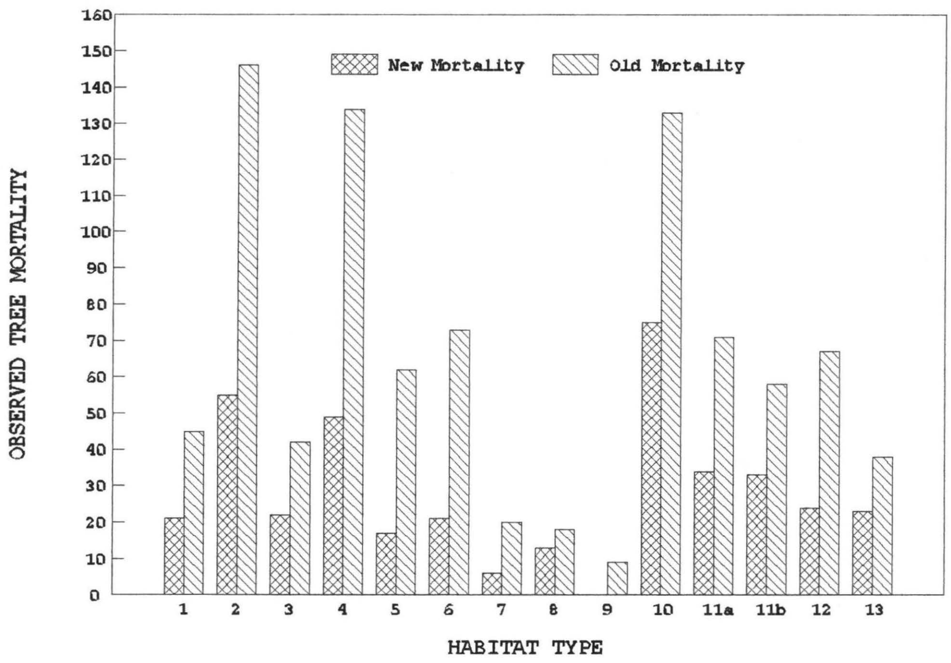

Figure 23: Elephant induced tree mortality, contrasting old and new damage on all tree species by Klaserie Private Nature Reserve habitat type. New mortality is defined as ≤6 months and old damage as >6 months to 15 years prior to data collection. Illustrating proportion of new damage relative to old.

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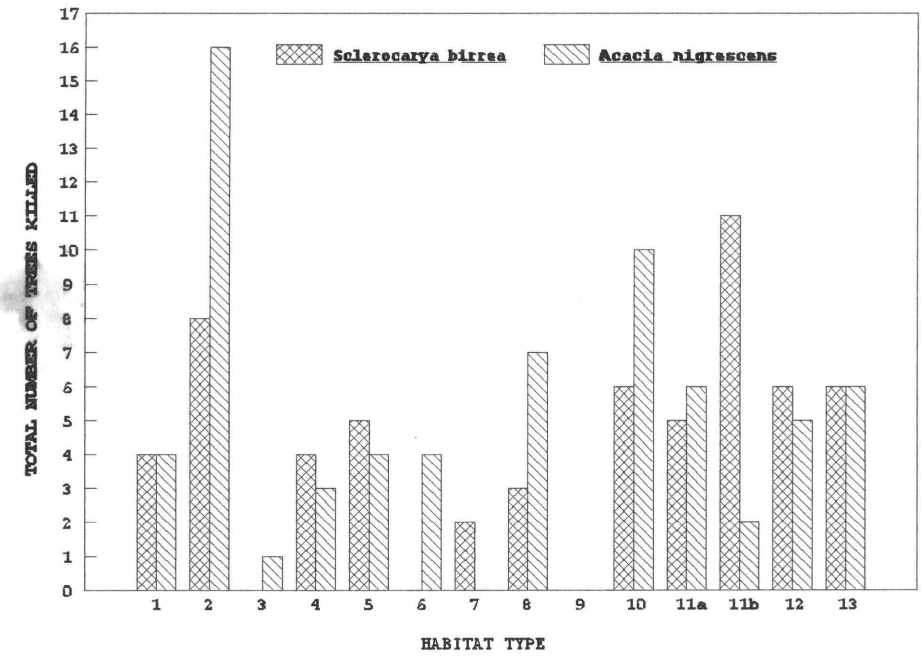

Figure 24: New elephant damage on two key tree species by Klaserie Private Nature Reserve habitat type. Based on data gathered in all habitat types 1990-1992, where new mortality is ≤ six months prior to data collection and old mortality > six months to about fifteen years prior to data collection.

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SAS (Statistical Analysis System, the operating system for CATMOD) was utilized to perform a correspondence analysis specifically for all recorded, elephant induced, tree mortality and habitat data, according to the methodology described in Chapters 3 & 4. A scatter diagram of the correspondence analysis represented in Figure 25 (Hill 1974).

The location of Sclerocarya birrea in Figure 25 near the intersection of both axes confirmed its preferential selection by elephant (Beardall et. al. 1984, Greenacre 1984). The proximity of habitat types 2 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Western Extension), 11b (South Eastern Mixed Woodlands), 10 (Acacia nigrescens-Grewia spp.), and 13 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Southern Extension) coincided with data displayed in Figure 22. Likewise the position of Acacia nigrescens indicated its high selection rate by elephants and confirmed the occurrence of a greater mortality likelihood for Acacia nigrescens in types 10 (Acacia nigrescens-Grewia spp.), 11b (South Eastern Mixed Woodlands), 9 (Mixed Acacia spp. Shrubveld-Klaserie River Corridor) and 13 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Southern Extension) (Hill 1973).

The scatter diagram also showed a triangular relationship between Sclerocarya birrea, Acacia nigrescens and type 13 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Southern Extension)); corresponding with data showing equal new mortality in Figure 24. The correspondence analysis also shows the relationship

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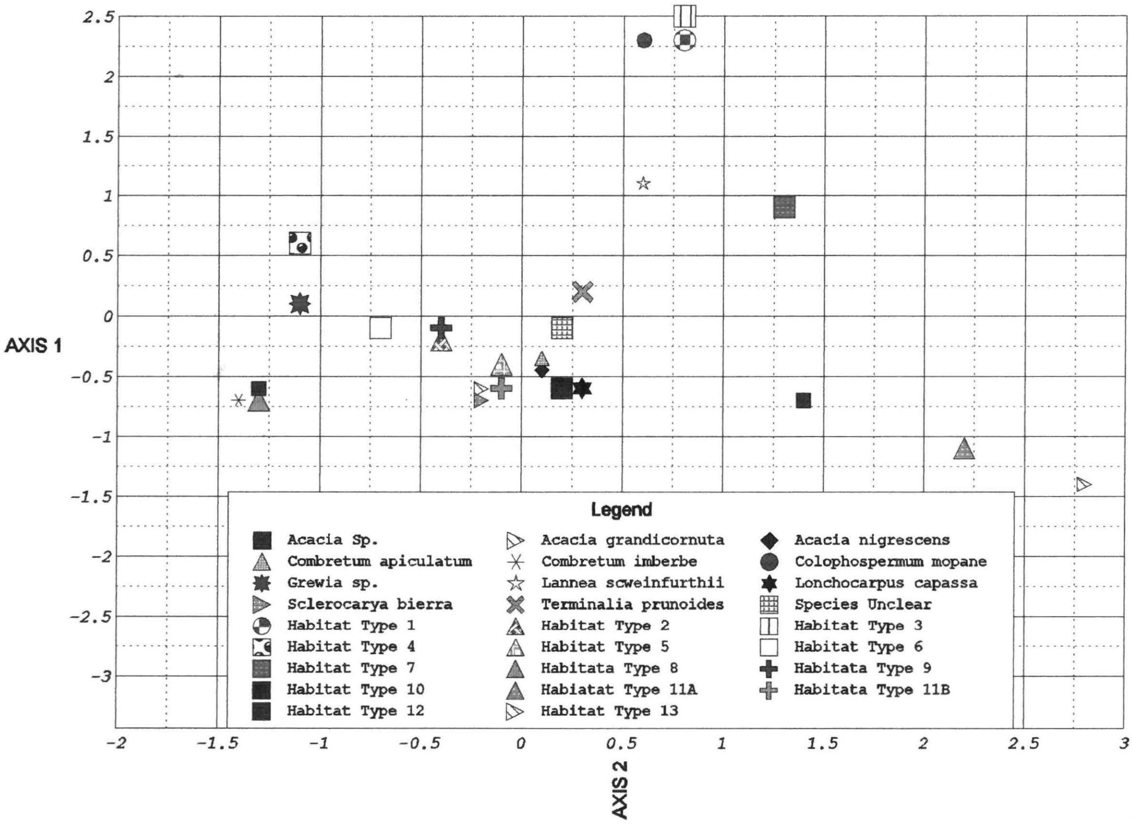

Figure 25: A correspondence analysis generated scatter diagram showing the relationship between elephant induced tree mortality and Klaserie Private Nature Reserve habitat types, from data gathered 1990-1992. Showing elephant preference by tree species and habitat type.

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between the selection of Colophospermum mopane and types 1 (Combretum apiculatum-Commiphora mollis, Grewia spp. Short Woodland-Oliphants River periphery), 3 (Colophospermum mopane Woodland and shrubveld-Oliphants River periphery) and 7 (Colophospermum mopane Dominant Mixed Woodland and Shrubveld with Combretum apiculatum Intrusions). These relationships were expected when considering the preponderance of Colophospermum mopane in these habitat types, as Colophospermum mopane is the predominant available browse in these types. Mortality on Acacia Spp., other than Acacia nigrescens, is most likely to occur in Klaserie habitat type 11a (South Western Mixed Woodlands). Likewise mortality on Combretum imberbe was heavily linked with Klaserie habitat types 8 (Western Mixed Woodlands) and 12 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodlands with Open Woodland Intrusion). Damage to Grewia spp. is most closely associated with habitat type 6 (Combretum apiculatum-Sclerocarya birrea, Grewia spp. Short Woodland-Eastern Extension). However, since Grewia spp. seldom achieve growth forms which would qualify it for inclusion in this study, this may merely indicate those sites where it has done so. Interpretation is after Greenacre and Vrba (1984).

Data presented in Chapter 4 tended to confirm the above data in all Klaserie Private Nature Reserve habitats, but particularly so for the wet season data. Attention is drawn to the data under Variable 39 (Sub-dominate woody species) and Variable 49 (crown cover) in this category. Data from Variable 39 (Sub-dominate woody species) show a clear affinity for elephant association with Sclerocarya birrea. The

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fact that no other tree species shows such an affinity is especially revealing of this relationship. The postulate of the presence of shade as an elephant attractant (Wheelock 1980) was given credence by data from Variable 49 (Crown cover) which showed clear elephant preference. Elephants are therefore shown to occur, by preference, in areas with a heavy mature tree canopy cover and a particularly high density of Sclerocarya birrea, at precisely the time when uprooting of such trees was most frequent (i.e. the wet season). The shade data also confirmed elephant presence in the immediate vicinity of other large, mature trees then (Coetzee 1979).

Other data from Chapter 4 which appeared relevant to elephants were those of kudu habitat use. Variables 41 (Old elephant damage), 42(New elephant damage), 43 (Damaged species) and 49 (Crown cover) under this heading clearly show that kudu are a negative indicator of elephant damage. It is unclear whether they avoid such damage intentionally or inhabit were areas which lacked the parameters chosen by elephants to damage the mature tree component. It seemed clearly significant that kudu are most likely to occur where elephants have not killed any trees in either the old or new categories.

DISCUSSION

The current study concurs with the body of literature on the topic of elephant feeding habits, specifically in reference to the occasionally destructive habits (Wing and Buss 1970, Jarman 1971, Guy 1976, Coetzee

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1979, Thomson 1986, Viljoen 1991, and Thomson 1992). While Viljoen and Bothma (1990) show exceptions to this rule, they also show the preferential feeding habits on certain woody plants, as does Viljoen (1989). While an isolated population may differ in its destructive feeding habits, this does not negate the larger body of data compiled on the continent. Viljoen (1989) further shows the affinity of elephants for certain habitats and woody species in this isolated population. In this context Coetzee (1979) shows similar habitat selection traits and elephant preference for Sclerocarya birrea and Acacia nigrescens in the adjacent Kruger National Park. Coetzee's study (1979) particularly concurs with the data in the current study which is important as it conceivably involves portions of the same elephant population.

De Villiers (1992) and De Villiers et. al. (1992) show similar but more limited impacts by elephant in the Klaserie Private Nature Reserve than do data from the current study. However, De Villiers work differed in methodology, being oriented toward vegetation sampling rather than the actual use of habitats by herbivores. De Villiers (1992) study involved only 11 transects and did not cover all 14 Klaserie habitat types. The fact that De Villiers (1992) documented elephant-induced mortality on Acacia nigrescens and Sclerocarya birrea in the same areas as the current study add particular credence to the findings in this chapter (Table 11).

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Table 11: The number of trees per ha and the percentages of trees untouched, changed to shrub form, and killed at the time the data was gathered. The data of all the management areas was gathered by species, except in the case of *Colophospermum mopane*, which occurred on management areas 3 and 7. After De Villiers *et*. *al*. (1992).

Tree species	Trees/ha	% Untouched	% To shrub	% Dead
Acacia nigrescens	36,3	83,3	5,8	10,9
Colophospermum mopane	101,6	83,1	16,9	0.0
Combretum apiculatum	44,2	48,9	41,6	9,5
Sclerocarya birrea	6.5	78,6	10,7	10,7

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CONCLUSIONS

The analysis of data collected in this study strongly indicated an accelerated rate of elephant-induced tree mortalities on all Klaserie Private Nature Reserve habitat types for the period beginning in 1989 and continuing through 1992. Indeed, it would seem odd if this were not so given the documented population irruption of elephants corresponding with the study period. Even considering the caveat expressed in Chapter 3 regarding the data collection methodology as possibly being geared towards herbivore micro-habitat preferences (Hobby & Hanley 1990), the evidence still appeared overwhelming. Particularly as the bulk of data collected in this study was determined by the presence of herbivores other than elephants.

It must also be noted that all data gathered in this study were collected along graded roads or bush tracks and hence it involves already made travel routes which may invite heavier than normal elephant use. However, given the density of roads and tracks on the Klaserie Private Nature Reserve, the total transect length of 326 kilometres, and the transect width of 500 m (Chapter 3) and (Table 2), the removal of sampling along or near roads from management considerations would entail ignoring a surface area equalling 123 km^2 or 20% of the entire Klaserie Private Nature Reserve. Even if the presence of roads and tracks speeded up the rate of tree damage, these routes exist and the resultant impact of elephants on the vegetation concerned, especially must be understood and management strategies

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must be formulated accordingly. The potential of the Klaserie Private Nature Reserve to be one of only a few private reserves, by virtue of its size, capable of sustaining a viable elephant population with an inbreeding coefficient of less than one percent (Du Toit 1991) is not insignificant. Ecologically it is to the advantage of the reserve to maintain such a population over the long term because of the potential of the elephants to help maintain a diversity of cover types (Wing & Buss 1970). Habitat diversity is essential, not only for the viability of elephant populations, but for other types of animals as well. It is the location and size of the Klaserie Private Nature Reserve which make it a prime candidate for the maintenance of regional biodiversity (Salwasser 1988). Nevertheless, the maintenance of an elephant population in excess of the ecological carrying capacity of the area will only lead to further habitat degradation, ironically in the form of increased bush encroachment (Eltringham 1979, Thomson 1986), a situation which is unacceptable within the framework of the Klaserie management goals.

The current status of elephant in the international community often makes biologically sound management a secondary consideration to political agenda's (Mulder 1991). This may be more critical in those few situations where elephants are privatised to some degree (Weaver 1991). By virtue of its location, both geographically and politically, The Klaserie Private Nature Reserve will undoubtedly be under increasing scrutiny for its elephant management policies, if for nothing else. Indeed, it's annual share of the Republic of South

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Africa's Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES) make its elephant and therefore the whole Klaserie Private Nature Reserve, a highly visible player in the international arena. In 1991 the Klaserie Private Nature Reserve harvested a full 20 percent of South Africa's CITES elephants. In 1992 that figure rose to just under 33 percent of all of South Africa's CITES elephants harvested (Postma 1992). Such figures emanating from a privately held entity will not long go unnoticed, or unchallenged. The need for a scientifically based harvesting quota, then, becomes self-evident.

While the political difficulties associated with a programme involving the sustainable harvesting of surplus elephants cannot be underestimated, neither can the biological realities necessitating it (De Vos Bengis & Coetzee 1982). There is clear evidence that the population level of elephants on the Klaserie Private Nature Reserve in the period 1989-1990 exceeded the ecological capacity of resilience of the mature tree component. The non-sustainable mortality rate of the mature tree component shows this conclusively. The implications of this mortality to the overall ecology of the Klaserie Private Nature Reserve; the botanical diversity, and the other grazing species in particular, cannot be overlooked. In regard to other herbivores it is clear that the ramifications to their carrying capacity could be negatively affected (De Villiers, Hugo, Terblanche & Kok 1990).

Regarding the botanical component; the complete removal of some woody

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species could occur without specific management to prevent it. The situation with Sclerocarya birrea , is emphasised due to its importance to other animals, its relative scarcity as an overstory component, and its preferential selection by elephant. The regeneration rate of woody species on the Klaserie Private Nature Reserve is unknown, but is likely to be episodic (Bothma 1989). The mature tree component in existence today is largely a product of a time of low elephant densities. Given the radically altered elephant-herbivore situation on the Klaserie Private Nature Reserve as contrasted with the recent known historical situation, there is no guarantee that species such as Sclerocarya birrea can reestablish successfully, let alone maintain essential growth forms and densities.

Considering this situation, it would be prudent to take specific steps to reduce and maintain the elephant stocking rates in the area to levels nearer to those suggested by De Villiers (1992). The keystone of such a management strategy should be the continuation of population regulation utilising sport hunting. The Klaserie Private Nature Reserve has the potential of doing this on a sustainable basis, perhaps the only private reserve currently capable of doing so. This could be pivotal in maintaining elephant hunting as a viable economic incentive for elephant management on private lands in South Africa, which, in turn, could prove to be pivotal to the continued existence of elephants in South Africa (Pienaar 1983).

Not only does such a strategy produce the capital needed to further

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habitat research and improvement, but it targets that component of the elephant population most likely to inflict mortalities on the mature tree component, specifically, those larger bull elephants which have demonstrated such a habit (Guy 1976). Such individuals should be identified, by spoor, and targeted for removal. While some damage of trees ~~is~~ will occur constantly from normal elephant feeding activities, this is easily differentiated from destructive behaviour such as the methodical uprooting of mature trees. In the eventuality that such selective hunting does not eliminate or substantially reduce the problem, due, for example, to a relative absence of a mature bull component, then hunting and culling of cows and calves could be instituted to lower populations, and hold them to pre-1989 levels.

Finally, a further programme of research should be implemented to determine the optimum stocking rate for elephants in the Klaserie. Such research must consider the impact on the botanical component of the area and its subsequent effects on other herbivores. Specific research should include the identification and quantification of the tree component by vegetation type and the estimation of the replacement rates of the key species under present and desired future herbivore stocking rates. While the Klaserie Private Nature Reserve currently has an excellent decision-making and management strategy regarding mammals (Weaver, Bothma & Leibnitz 1994), it lacks comprehensive direction in the botanical realm; in particular in managing the woody component in a sustainable way.

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Elephants have the greatest ability to alter habitats, next to mankind, (Wing & Buss 1970), which has long been recognised in the literature as "the elephant problem" (Eltringham 1979). This is true for both restricted and unrestricted ranges: Ritchie, then, Game Warden of the Kenya colony from 1923 until 1949, spoke of both the destructive feeding habits of elephants and the need to limit their conflicts with mankind over a broad range (Hunter 1952). This happened in a time and context that was a vast, free-ranging situation. It would not seem possible, then, that any conceivable removal of fencing, or other partial barriers, between The Klaserie Private Nature Reserve and adjacent reserves or the Kruger National Park, or even Mozambique; would serve to create a situation, large enough to be free of conflicts of man with elephant or elephants with a "restricted" habitat. Therefore, it is wise to provide elephant with special considerations and a conservative, circumspect management approach based on sustainable long-term conservation and utilisation goals specific to the Klaserie Private Nature Reserve, its habitats and fiscal situation.

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CHAPTER SIX: MANAGEMENT RECOMMENDATIONS

BACKGROUND

Carrying capacity as discussed in Chapter 1, combined with the economic capacities of any management body are only part of the scenario. In the specific case of the Klaserie Private Nature Reserve, the above factors must certainly be considered. Further complications arise from political considerations, however. This is brought on by the multiplicity of ownership within the Klaserie Private Nature Reserve and as embodied in its constitution (Weaver, Bothma and Leibnitz 1994). Although a strong commitment to the full diversity of native herbivores is expressed by reserve management and the constitution, the issue is not simple. Strong demands for biltong hunting by some members of the reserve create a demand for the maintenance of high numbers of huntable herbivores such as the impala. Equally strong political considerations lobby for maintaining high numbers of elephants from an aesthetic and ethical viewpoint. Clearly these demands must be taken into account, with all of their implications, as any such final management decisions are never made strictly on a biological basis alone. Allocation of acceptable population levels for various types of herbivore, then, are being made on a political basis first and must then be refined in an ecological sense.

It is within the constitutional ability of the owners of the Klaserie

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Private Nature Reserve to determine what level and type of carrying capacity they desire to attain. For all intents and purposes, socio-economic and ecological carrying capacity is a management prerogative within the multiple socio-economic and ecological parameters noted above. Certainly this is best illustrated by the selection of herbivore types and numbers when setting management goals.

Furthermore, tools such as supplemental feeding could be employed by a reserve the size of the Klaserie if desired by popular consensus or economic returns (Weishunh and Sciba 1989). Indeed, this has occurred on the reserve in isolated incidents during droughts in the past to protect valuable animals; specifically the white rhinoceros and cape buffalo (Leibnitz, pers. comm.*). However, scientifically this is generally not considered to be a viable tool in managing herbivores on large areas under sustained conditions and is usually indicative of a failure in management strategy, and it is generally not economically practical (White 1987). As a consequence it should not be considered as a management option except for unusual or catastrophic situations which are not easily predicted or rectified ecologically.

The aims of this Chapter, therefore, are the enumeration of specific points raised during the course of this study which can enable the

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owners of the Klaserie Private Nature Reserve to attain their goals within the context of the guidelines of the constitution of the Klaserie Private Nature Reserve and its ecological, economical and socio-political realities.

DISCUSSION

Penny (1987) has noted that animals such as rhinoceros and elephant increase numerically when they are at approximately at 50 to 60 percent of their habitat's carrying capacity. Considering this, the examination of the data collected during the course of the current study relative to the identification of habitat areas, coupled with known historical situations and recent population trends yield some obvious conclusions. The consideration of other known factors such as culling rates, personal (owner) preferences, habitat manipulations, and climatic abberations further refines these conclusions relative to the species involved.

The observations of other researchers in adjacent and similar situations are also relative to the specific situation. The situation during the course of this study was one of confinement by fencing for most animals involved. This has now been substantially altered due to the removal of some of the boundary fences, most notably the boundary fences with the adjacent Kruger National Park and Timbavati Private Nature Reserve. Analysis of the collected data, in consideration of the above factors, should therefore yield a sound

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concept of the carrying capacity of the Klaserie Private Nature Reserve relative to individual herbivore species and should also provide guidelines for habitat (Chapter 7) and herbivore manipulations (Thomson 1986).

MANAGEMENT PROPOSALS

Utilising the above principles and the data available from the current study some obvious conclusions are immediately reached. Firstly, it is obvious that significant habitat changes have occurred within historic times which have greatly altered the ability of Klaserie habitats to support certain herbivores. Most notably the tall grass habitat component that was probably present within the past half century has now been virtually eliminated. The situation with sable clearly illustrates this change. The recent, tenuous presence of sable antelope on the Klaserie Private Nature Reserve, when some 70 years ago they were abundant and shot for rations, and their failure to reproduce in any significant manner now, is typical of a herbivore attempting to survive in a marginal habitat situation. The demonstration of a viable long grass component and a healthy sable population on the "Madrid" game ranch near the Klaserie Private Nature Reserve furthers the probability of an historical long grass component on the Klaserie (Venter 1994). Conversely, the current overall habitat situation on the reserve has altered drastically to favour the once incidental impala (Petrides 1974) (Pettifer and Stumpf 1981).

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The provision of multiple and well-dispersed water points (Zambatis 1982) has given herbivores an ability to disperse, year round, into areas which they could previously access only on a seasonal basis. The data presented by Scholes (1987) also indicates that widespread bush encroachment is likely occurring now. This is underscored by the necessity of implementing large scale, costly, erosion control projects in areas identified in this study as primary grazing areas. The demonstrated concentration of grazing oriented herbivores on these grazing areas adds credence to this viewpoint (Chapter 3). The data on impala presented in Chapter 4, (Figure 17) also show a disproportionate situation in terms of accepted recommendations regarding stocking rates and ratios of grazers, mixed feeders and browsers (40:40:20 percent respectively) as suggested by Mentis and Duke (1976). Lastly, the elephant irruption which occurred during the course of this study (Chapter 5) indicates, among other things, a relative lack of a mature tree component in the adjacent region with serious implications for the survival and maintenance of other species subsequent to the fence removal.

Two decades of management within a relatively confined situation has therefore allowed the herbivores present to shape local habitats on the Klaserie Private Nature Reserve in an unprecedented manner. This is cumulative to unquantified impacts resulting from prior cattle grazing. The present concentration of large numbers of herbivores, most notably short grass grazers and mixed feeders, on a diminishing grazing component have contributed to a situation which is resulting

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in bush encroachment, erosion and a general degradation of the habitat quality. The virtual elimination of fire as a habitat factor under current management approaches has undoubtedly exacerbated this situation (Gertenbach 1983) (Trollope 1990).

Elephant-induced mortality to the remaining mature tree component is the final factor in the conversion of Klaserie habitats into areas which favour shrublands over savanna and other vegetation associations. Relatively static population trends for those grazing herbivores most likely to reflect declining habitat conditions (eg; sable antelope and blue wildebeest) validate this conclusion. The robust performance of browsing species and mixed feeders (eg; giraffe and impala), at historically high levels, also indicate a shift in habitat capability favouring such herbivores (Coe 1980).

MANAGEMENT RECOMMENDATIONS

A shift in the Klaserie Private Nature Reserve management strategies/policies are necessary should the current trend be unacceptable. This shift must consider the biological, economical and political realities of the current situation and the ultimate destination which will be reached should changes not occur. The following recommendations, to be viable, must be presented in a popular format, to the owners, so as to gain enough support to within the context of the reserve's stated goal of recovering the full spectrum of native herbivores and maintaining diversity on a

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sustainable basis:

Black rhinoceros

Black rhinoceros reintroduction into the Klaserie Private Nature Reserve appears feasible under current habitat situations. Specific habitat features required by the black rhinoceros, such as dispersed water-holes, _Acacia_ thickets, and relative security are abundant. Tall grass, although of minor importance, is available in limited quantities where it grows protected by thorn shrubs (Penny 1987). It is uncertain whether this tall grass is utilisable by the black rhinoceros. The negative factor to reintroduction is the possibility of calf predation by the healthy population of predators present on the reserve. Positive factors include security from poaching and beneficial international publicity. Reintroduction of a limited number of the black rhinoceros is therefore recommended. Monitoring will then indicate whether the numbers may be increased and to what population level this can be done.

Blue wildebeest

Blue wildebeest appear to be at or near their grazing capacity as dictated primarily by lack of suitable habitats and climatic affects (Talbot and Talbot 1963). Blue wildebeest numbers have recovered slowly from the effects of the drought early in the previous decade. Substantial future increases are unlikely due to the limited abilities

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of grazing habitat availability and the affinity of the blue wildebeest for such areas as demonstrated here(Chapter 4)(Whyte 1985). An alteration of Klaserie Private Nature Reserve policy to favour blue wildebeest habitat and consequently that of other grazing species, is recommended.

Cape buffalo

Buffalo populations on the Klaserie Private Nature Reserve do well, except during droughts. Based on buffalo counts over the past decade, the buffalo may be near its ecological capacity on the Klaserie Private Nature Reserve under the current management approach, and particularly in view of the current precipitation patterns. The niche occupied by buffalo is undoubtedly being impacted on by the concentration of grazing species as delineated in Chapter 3. Habitat policies designed to reduce bush encroachment could result in an overall increase in the buffalo population (Sinclair and Gwynne 1972). Such policy alterations are recommended to favour the buffalo on appropriate habitat areas.

Elephant

Elephant population regulation as outlined in Chapter 5 should be implemented as soon as possible to reduce further impacts on the mature tree component. Elephants are likely to be exceeding their carrying capacity under present conditions. However, the elephants

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ability to alter the overall habitat situation must be viewed as the primary issue (Eltringham 1979). This is particularly true in consideration of the bush encroachment problem. A management target of reducing mortality on the mature tree component, by removing those elephants who demonstrate destructive feeding traits, should be effected with a simultaneous monitoring programme.

Giraffe

Giraffe currently represent the highest biomass of any herbivore on The Klaserie Private Nature Reserve (Table 6). They are probably below their browsing capacity and are probably also being limited only by a relatively low fecundity, fairly heavy predation pressure and culling for rations (Hall-Martin 1974). Giraffe biomass on the Reserve is reflective of a browse-dominated forage base which has altered in historic times. The giraffe situation adds credence to the probability of bush encroachment being widespread on the Klaserie Private Nature Reserve. No alteration of Klaserie Private Nature Reserve policy is suggested for giraffe.

Impala

The ability of the impala to dominate numerically on the Klaserie habitats demonstrates that the current situation favours them over other species (Munro 1980). This is further underscored by their ability to rebound numerically even under the steady pressure from

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biltong hunters and commercial culling. Impala are likely not near their ecological capacity in the context of the Klaserie Private Nature Reserve. However, they are probably having a negative impact on the remaining grazing component as demonstrated by their concentrations on these areas and particularly their affinity for over utilised areas (Munro 1979). Impala numbers should be reduced drastically if a diversity of herbivores is to be fostered and the recovery of the grazing component of the Klaserie is to be effected.

Kudu

Kudu appear to be at or near their ecological capacity for the reserve as demonstrated by their population trends over the past decade. Kudu are most likely limited by climatic factors and by relatively limited habitats (Thomas 1979), primarily riparian in the Klaserie context, which are unlikely to be increased substantially by management policy changes (Novellie 1983). It is possible that the removal of boundary fences, particularly with the Kruger National Park could have a substantial affect on the Klaserie kudu in the form of kudu emigration out of the reserve. As a consequence no alteration in Klaserie Private Nature Reserve policy is recommended for kudu.

Roan antelope

Roan reintroduction is not recommended at present for reasons given under (sable) below. The lack of appropriate habitat would make the

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failure of such an effort likely. Reestablishment of a long grass component on the reserve is a vital component in bio-diversity and as a prerequisite to roan reintroduction (Joubert 1976).

Sable antelope

Sable appear to be occupying the remnant of a niche on the reserve. It is likely that they are near their carrying capacity under present conditions, as demonstrated by their inability to increase as expected. Habitat alterations (Chapter 7) to restore the long grass component are necessary if the sable is to be more than a curiosity on the reserve. Research on the "Madrid" game ranch, near the Klaserie Private Nature Reserve indicates that adequate sable habitats are possible within the local area (Venter 1994). An investigation into the restoration of sable habitats and an implementation of such is recommended.

Tsessebe

Tsessebe are currently present in other reserves near the Klaserie. However, the affinity of tsessebe to more open, savanna, habitats argues against their reintroduction into Klaserie Private Nature Reserve habitats unless substantial alterations of the current situation are elected. Reintroduction of tsessebe under present conditions would likely result in a situation similar to that of the sable antelope. It is therefore recommended that the Klaserie Private

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Nature Reserve management policy be altered to favour habitats desirable to tsessebe and sable antelope as this is in line with a goal of reduced bush encroachment and the general enhancement of the grazing components on the reserve.

Warthog

Warthog are well distributed in suitable Klaserie Private Nature Reserve habitats. They appear to be limited primarily by climatic conditions. They are probably at or near the ecological capacity under current conditions (Leuthold 1978). Even if the grazing component is improved towards a more tall grass situation, this should not seriously endanger the warthog there. No alteration in Klaserie management policy is suggested for warthog.

Waterbuck

Waterbuck appear to be a species occupying a small niche on the reserve. Waterbuck are currently a small population which appear to be highly responsive to climatical changes. No policy change is recommended for waterbuck as they appear to be near their carrying capacity. However, a change towards a better quality tall grass component will also favour the waterbuck.

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White rhinoceros

Current white rhinoceros populations on the Klaserie Private Nature Reserve are too low to formulate an accurate assessment of their ecological capacity. However the potential habitat needs of the species are available within the range of habitats present on the reserve and the white rhinoceros' relative insusceptibility to predation is an additional positive element. It is recommended that the grazing habitat policies on the Klaserie Private Nature Reserve be altered to favour the white rhinoceros in tandem with other grazers of equal ecological requirements.

Zebra

The zebra is another grazer which probably is near its ecological capacity on the Klaserie Private Nature Reserve. Zebra numbers dropped during the drought of the early 1980's and have responded slowly during the remainder of the decade. Zebra populations appear to mirror precipitation trends on the reserve, further substantiating the belief that they are near their ecological capacity there (Ngethe 1976). No specific policy change is recommended for zebra, as they will probably continue to respond to overall habitat policies favouring the grazing species on the Klaserie (Casebeer and Koss 1970) without being reduced to critically low levels.

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CHAPTER SEVEN: CONCLUDING DISCUSSION AND MANAGEMENT PROPOSALS

INTRODUCTION

This final chapter attempts to reflect the author's personal views and observations (Subjective) acquired during the course of this study as well as an objective viewpoint based on the findings in this study. The purpose is to present a balanced evaluation of the current progress of the Klaserie Private Nature Reserve toward an ecologically, economically and politically viable management strategy. As noted in Chapter 6, management decisions are the final determinant in the biological processes which occur on the Klaserie Private Nature Reserve. Recommendations on stocking rates, habitat manipulation and general management considerations should be made from a balanced overview.

OBJECTIVE EVALUATION

Current calculations on carrying capacity (Table 6) fail to fully recognise the qualitative factors of the preferred grazing habitats which are showing increasing impacts, particularly in the areas of grass composition and bare ground ratios in preferred grazing areas (Chapter 3). Further increases in the numbers of grazing herbivores, although desired by the membership and management of the Klaserie Private Nature Reserve, can be accomplished only at the detriment of the grazing habitats. Further introductions of additional grazing

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herbivores, for species diversity, can only come at the expense of existing grazing herbivores. Results in this study show conclusively that impala and warthog (less importantly due to their numbers) are indicators of heavily utilised and over-utilised habitat situations (Mason 1982, Wentzel et. al. 1991). The impala has shown no evidence of being near their ecological capacity as indicated by the trends in their population. Impala are shown in this study, and in the work by Wentzel et. al., to be primarily associated with "INCREASER II" grass species. The preponderance of the impala biomass is therefore indicative of declining grazing habitats on the Klaserie Private Nature Reserve, as well as on-going bush encroachment.

The elephant irruption of 1989-1992 was shown in this study to have had an impact on the mature tree component (Chapter 5). Further, impala were shown to have a preference for areas where elephant-induced tree mortalities occurred (Chapter 4). The ability of elephant to alter their habitats, and those of other herbivores is well documented in the literature (Guy 1976, Eltringham 1979, Joubert 1986, Cohen 1987). The ecological effect of an increased elephant population coupled with the high impala population has, therefore, had a deleterious effect on Klaserie Private Nature Reserve habitats.

SUBJECTIVE EVALUATION

In the authors opinion the practical way towards attaining a viable ecological and economical carrying capacity for the Klaserie Private

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Nature Reserve, which would be acceptable to the owners, appears to have to be achieved by a dual course. First is the attainment, through research, of a clear understanding of the multiple factors influencing the carrying capacity of the herbivores on the area. Second is the conveyance of this information to all of the decision-making parties in a clear manner. The ability to make informed, biologically viable, decisions is most likely to occur when the all facts are known by all parties involved. In the case of the Klaserie Private Nature Reserve, accurate calculation of absolute or ecological carrying capacities are useless if they are not supported politically and socio-economically. The following is suggested as a basis for achieving this state.

STOCKING RATES

A determination of the ecological capacity of the Klaserie Private Nature Reserve, from an individual herbivore species perspective, can be best achieved by a continuation and intensification of the current population monitoring programme. Species with little or no utilisation can be thereby identified relative to their ecological capacity. Good monitoring vehicles are the common waterbuck and\or the white rhinoceros. Failure of these herbivores to increase in numbers over time, as expected relative to their known fecundity and habitat requirements, should indicate that they have either reached their ecological capacity or that minimal or no suitable habitats exist on the reserve and that they are occupying atypical or marginal

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habitats there (Thomson 1992).

In tandem with this approach there should be the delineation of sub-population areas for those species which are utilised either for sport hunting or for rations (Brooks 1982, De Vos _et al_. 1982). This approach would be most valuable for the monitoring of a herbivore such as the blue wildebeest. The applicability and validity of this concept as a management tool on large areas has already been demonstrated in North America (Edge _et al_. 1987). This approach has also been proven by Smuts (1974) on large conservation areas analogous to the Klaserie Private Nature Reserve in South Africa. Such an approach would be important in the management of identified, overutilised, areas on which accelerated erosion or bush encroachment may be occurring (Chapter 3).

In taking this dual approach, there remains the definite need to monitor the reserve habitats continually and floristically. Modifications of existing habitats by overutilisation and/or bush encroachment can have a deleterious effect on a given herbivore's ability to adapt and fully realise express its ecological capacity within the context of the reserve (Snyman 1991). Thus meaningful and careful and continuous monitoring remains essential in the Klaserie Private Nature Reserve. Such modifications are occurring on the reserve. Scholes (1987) work has already demonstrated the competitive advantage of woody plant species in an area such as the Klaserie Private Nature Reserve. Thus monitoring of the Klaserie Private

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Nature Reserve's habitats should be most intensive on its demonstrated grazing habitats (Chapter 3), but particularly so on habitat types 8 (Western Mixed Woodlands), 9 (Mixed *Acacia* spp. Shrubveld-Klaserie River Corridor), 10 (*Acacia nigrescens*-*Grewia* spp.), 11a (South Western Mixed Woodlands), 11b (South Eastern Mixed Woodlands), and 13 (*Combretum apiculatum*-*Sclerocarya birrea*, *Grewia* spp. Short Woodland-Southern Extension).

The economic carrying capacity for a given species is generally an approximation of one half that of the species' ecological capacity or equilibrium population (Scogings 1988). This equates to a stocking rate which is management-oriented, hence a product of the political process on the Klaserie Private Nature Reserve. Therefore the sociological (owner's choice) carrying capacity must be accommodated here. Without support from the majority of Klaserie Private Nature Reserve owners, no attempt to manage the reserve in a scientifically viable manner will be successful. Generally, the owners prefer being able to view the full spectrum of lowveld fauna, with ample hunting opportunities.

HABITAT MANIPULATION

A serious need exists for efforts to be begun to begin to improve the grazing habitats on the Klaserie Private Nature Reserve substantially (Chapters 3 and 6, Appendix A). Work done in mopane-dominated habitat

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types by Scholes (1987) has demonstrated that highly productive type conversions, of at least a temporary nature, are possible there. There is a broad management need to expand the grazing habitats on the reserve where this is both ecologically and economically viable. Habitat conversions are expensive and time consuming as noted by Scholes (1987). The same is true for erosion control projects on the southern types in the reserve. In the past these efforts have been partially subsidised by the state. This may or may not continue under the new government. It is therefore prudent to assume that the agricultural subsidies for this type of work may be a policy of the past. Sound habitat management should therefore in the future plan for and preclude the need for more erosion control work. The keystone of habitat manipulation, particularly in the southern grazing types, must be the reduction of the bare ground percentages (Figure 10). Only by the re-establishment of a viable grass and forb cover can the current negative habitat trends be reversed.

These goals will not be easy to achieve. However the following, specific, steps are recommended to begin to achieve them:

1. The institution of an aggressive programme of habitat manipulation with fire as a tool. New technologies in fire management can be used to overcome poor fuel loads, particularly the lack of "ladder" or herbaceous fuels (Weaver and Benscoter 1989). This has often been cited as a major reason for not introducing prescribed fire. Bush clearing can also be used effectively as an ignition base and

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a fire-break for adjacent areas with suitable preparation under favourable climatic conditions. Alternatively, aerial ignition utilising intense heat sources such as F.A.E (Fuel Air Explosive) can overcome a lack of fuel loading or unfavourable fuel moisture by instituting a localised fire weather pattern which is self-sustaining and of an intensity sufficient to achieve habitat conversion. Military assistance in such projects may be pursued by putting forth the premise that such weaponry must be tested and public support, and budgeting, for such testing can be significantly enhanced under the public relations "umbrella" of sound conservation. Such projects must, however, be of sufficient size so as to avoid being an attractant to local herbivores thus negating the value of the project.

2. The control of herbivore access to areas being improved is a prerequisite for the ultimate success of such projects. Habitat improvements, whether with fire or mechanical manipulation, rapidly lose their value if herbivores quickly utilise the emergent, succulent, vegetation produced (Trollope 1990b). Access control can be accomplished by deliberate culling of local populations, control of waterpoints (Zambatis 1985), or the acquisition and deployment of high-tensile, New Zealand style, electric fences with portable solar power. Of the three options the control of water points would appear to be the most feasible on the Klaserie (Western 1975). Such a strategy would face opposition by farm owners who were affected in a given year.

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However, this might be overcome with sufficient education as to the long-term benefits. Use of this strategy for several years could provide a suitable, herbaceous, fuel source for future traditional fire management (Trollope 1990b).

3. The investigation of the merits of re-establishing a tall grass habitat niche on the reserve should begin immediately. To accommodate the full spectrum of potential native herbivores, any habitat programme undertaken must consider this approach well. The early identification of historical or remnant tall grass sites should be established prior to the inception of habitat manipulation programmes. Sufficient seed sources should be identified and obtained where this option is viable. Controlled herbivore access as stated under point 2. above would be a critical element in the success of such a project (Vesey-Fitzgerald 1960) and must be managed for.

4. The monitoring of all habitat improvement or conversion projects must be an integral part of any such projects and must include, as a minimum, the monitoring of herbaceous trends and herbivore use intensities. Stocking rates must be commensurate with the forage produced. The strategy must be qualitative with an emphasis on avoiding current trends where "Increaser II" species (Appendix A) dominate (Robbins 1983).

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GENERAL MANAGEMENT CONSIDERATIONS

The Klaserie Private Nature Reserve is fortunate in terms of its size and location. By virtue of these factors it is a de facto leader in the conservation of large mammals and their habitats in the lowveld. The conservation system in the Republic of South Africa is unique and offers many advantages over the more nationalised conservation systems in other parts of the world (Weaver 1995). However, the owners and management of the reserve must not rest on their current status and successes. Local political changes and an increasingly preservation-minded (anti-use) world media can work to undermine consumptive utilisation principles, the quasi privatised South African system, and the current status enjoyed by the reserve if, innovative and publicized projects are not introduced regularly. Fortunately, the Klaserie Private Nature Reserve has the habitat opportunities, management foresight and economic ability to do this. The owners of the reserve must be informed collectively of the necessity and benefits of proper resource management and utilisation, and must be motivated and encouraged to do so. The key element to success remains the proper, sustainable, management of the reserve's habitats (Trollope 1990a).

Since the conclusion of this current study, the removal of fencing between the Klaserie Private Nature Reserve and adjacent properties, particularly the Kruger National Park, has added another complicating

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dimension. This inclusion into the affairs of the Kruger National Park must be considered and studied carefully, as it has added a nationalised dimension to the largely privatised situation which existed previously. Extra caution in formulating management policy must therefore be appropriately accorded.

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HABITAT UTILISATION BY SELECTED HERBIVORES IN THE KLASERIE PRIVATE NATURE RESERVE, SOUTH AFRICA.

by

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SUMMARY

Habitat use by selected herbivores was recorded on identified habitats in the Klaserie Private Nature Reserve, between 1990 and 1992, to ascertain current habitat use patterns and their implications to the herbivore carrying capacity of the reserve. Observations were taken along replicable transects representative of each of the habitat types. Environmental and herbaceous factors were recorded at each observation site. Cumulative data were analysed for habitat condition and species occurrence. Further analysis was conducted by submitting the data variables to CATMOD analysis. This analysis was broken down

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by season and species. The CATMOD output generated highly specific correlations between a given herbivore type and its habitat use, by wet and dry season.

Immediately prior to the inception of the project, an irruption in the elephant population was noted concurrent with an increase in the mortality of the mature tree component of the reserve. Data specific to elephant-inflicted tree mortality were therefore gathered during the course of the study and were analysed separately. Past research specific to the Klaserie Private Nature Reserve was consulted and used to verify the results. From the analysis of the data it became clear that the grazing herbivores on the reserve were generally occupying atypical habitats which exhibited symptoms of overutilisation. Several grazing species were likely at their carrying capacity due to a lack of suitable habitats. Soil erosion was endemic in the more severely impacted habitat types and bush encroachment was occurring on large parts of the reserve. The elephant population irruption during the course of the study resulted in measurable damage to the mature tree component including disproportionate selection of Acacia nigrescens and Sclerocarya birrea. The combination of these results yielded a diagnosis of habitat degradation and habitat type conversion with a general decrease in grazing capacity over time.

Specific remedies, including stocking rate suggestions and habitat improvement/conversion projects were recommended.

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HABITATBENUTTING DEUR GESELEKTEERDE HERBIVORE OP DIE KLASERIE PRIVAAT NATUURE RESERVAAT, SUID AFRIKA

deur

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Leier: Prof. J. du P. Bothma

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OPSOMMING

Habitatbenutting deur geselekteerde herbivore van geidentifiseerde habitats op die Klaserie Privaat Natuurreservaat was tussen 1990 en 1992 aangeteken, om die gebruikspatrone van die herbivore, asook hulle invloed op die ekologiese kapasiteit van die reservaat vas te stel. Waarnemings is langs herhaalbare lyntranseckte van die omgewings-faktore en kruidstratum-kenmerke in elk van die habitattipes gemaak. Die data is vir habitattoestand en teenwoordigheid van diersoorte ontleed. Die data is per diersoort en per siesoen aan 'n CATMOD-

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analise onderwerp. 'n Sterk korrelsaie tussen spesifieke diersoorte en hulle habitatbenutting is in beide die nat en droe seisoen gevind.

Net voor die aanvang van die projek, was daar 'n sterk toename in olifantsgetale, met 'n gelyktydige toename in die mortaliteit van volwasse groot bome op die reservaat. Data met betrekking tot olifantskade en mortaliteit van bome is afsonderlik versamel en verwerk. Die resultate is met vorige soortgelyke data vir die reservaat vergelyk.

Alle inligting dui daarop dat die grasvreters oor die algemeen atipiese hapitats, wat tekens van oorbenutting toon, benut het. Verskeie tipes grasvreter het waarskynlik reeds hul dravermoe bereik weens die tekort aan bruikbare habitat. Gronderosie kom algemeen in die meer oorbenutte habitats voor.

Die sterk toename in olifantgetalle gedurende die studietydperk het meetbare skade aan die volwasse boomstratum tot gevolg gehad met buit verhouding groot skade aan Acacia nigrescens en Sclerocarya birrea. Die resultate van die studie dui verder op habitatdegradasie en -verandering met 'n algemene afname in weikapasiteit oor tyd op die reservaat.

Spesifieke remedierende aanbevelings met betrekking tot weikapasiteit, habitatverbetering en -rehabilitasie word gemaak.

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APPENDIX A: Veld condition assessment of the Klaserie Private Nature Reserve by habitat type, May 1988, by utilising key grass species (after Trollope et al. 1989). Included is a summary of the fuel potential and comparison of 1988 data scores with those of June 1987. No samples were taken in Klaserie habitat type 1 and 3 in 1988, two sample transects were taken in Klaserie habitat type 7. Data were collected and organised by erstwhile Transvaal Chief Directorate of Nature and Evironmental Conservation, Hans Hoheisen Wildlife Research Station, Hoedspruit.

DEFINITIONS USED: Decreaser species = Grass and herbaceous species which decrease when veld is overutilised. Increaser I Grass species and herbaceous species which increase when veld in underutilised. Increaser II species=Grass and herbaceous species which increase when veld is overutilised. Forage/fuel score is after Trollope and Potgeiter (1986).

(Forage/fuel score)	Potential	Forage:Fuel Ratio
>500	Very high	:
[400] [499]	High	:
[300] [399]	Medium	:
[200] [299]	Low	* : * = Actual score
<200	Very low	:

KLASERIE HABITAT TYPE 2:

			1988		1987	
		FREQUENCY	FACTOR	SCORE	FACTOR	SCORE
DECREASER	Cenchrus ciliaris		1.59	0.0	2.16	0.0
SPECIES	Digitaria eriantha	4.1	1.30	5.3	0.00	
	Panicum coloratum		4.25	0.0	2.90	0.0
	Panicum maximum	3.4	7.40	25.2	1.63	5.5
	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0
	Themeda triandra		2.29	0.0	3.10	0.0
	DECREASER TOTAL	7.5		30.5		5.5

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INCREASER	Hyparrhenia filipendula		3.09	0.0	4.92	0.0
SPECIES	Hyperparrhenia dissoluta		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREASER	Aristida barbicollis	14.9	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	Enneapogon cenchroides	3.4	0.00		0.00	
	Bothriochloa radicans	1.9	-0.77	-1.5	2.96	5.6
	Eragrostis rigidior	4.8	-3.13	-15.0	-2.76	-13.2
	Forbs	27.3	-0.01	-0.3	-4.09	-111.7
	Heteropogon contortus	1.1	0.00		0.00	
	Pogonarthria squarrosa	1.7	-1.48	-2.5	-0.92	-1.6
	Schmidtia pappophoroides	9.1	0.07	0.6	-1.50	-13.7
	Tragus berteronianus	0.1	-3.11	-0.3	-4.72	-0.5
	Urochloa mosambicensis		0.00		0.00	
				268.0		389.0
	INCREASER II TOTAL	64.3		-19.0		-135.0
	OTHERS	28.2	TOTAL	279.5		259.6
	TOTAL	100.0				

		Percent	Utilisation
TREND:	Decreaser species	7.5	Moderate
	Increaser I species	0.0	Under
	Increaser II species	64.3	Over * Type 2 Rating

KLASERIE HABITAT TYPE 4

			1988		1987	
		FREQUENCY	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	Cenchrus ciliaris		1.59	0.0	2.16	0.0
SPECIES	Digitaria eriantha	20.8	1.30	27.0	0.00	
	Panicum coloratum		4.25	0.0	2.90	0.0
	Panicum maximum	1.8	7.40	13.3	1.63	2.9
	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0

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		FREQ.	FACTOR	SCORE	FACTOR	SCORE
	Themeda triandra		2.29	0.0	3.10	0.0
	DECREASER TOTAL	22.6		40.4		2.9
INCREAS.	Hyparrhenia filipendula		3.09	0.0	4.92	0.0
SPECIES	Hyperparrhenia dissoluta		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	Aristida barbicollis	13.50	0.00			0.00
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	Bothriochloa radicans	1.50	-0.77	-1.2	2.96	4.4
	Enneapogon cenchroides	2.50	0.00		0.00	
	Eragrostis rigidior	1.30	-3.13	-4.1	-2.76	-3.6
	Forbs	30.60	-0.01	-0.3	-4.09	-125.2
	Heteropogon contortus	0.80	0.00		0.00	
	Pogonarthria squarrosa	0.90	-1.48	-1.3	-0.92	-0.8
	Schmidtia pappophoroides	5.30	0.07	0.4	-1.50	-8.0
	Tragus berteronianus		-3.11	0.0	-4.72	0.0
	Tragus berteronianus		0.00		0.00	
					268.0	[illegible]
	INCREASER II TOTAL	56.4		-6.5		-133.1
	OTHERS	21.0	TOTAL	301.9		258.9
	TOTAL	100.0				
		Percent	Utilisation			
TREND:	Decreaser species	22.6	Moderate			
	Increaser I species	0.0	Under			
	Increaser II species	56.4	Over * Habitat Type 4 Rating			

KLASERIE HABITAT TYPE 5

			1988		1987	
		FREQ.	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	Cenchrus ciliaris		1.59	0.0	2.16	0.0
SPECIES	Digitaria eriantha	9.90	1.30	12.9	0.00	
	Panicum coloratum		4.25	0.0	2.90	0.0
	Panicum maximum	4.80	7.40	35.5	1.63	7.8
	Setaria flabellata		2.52	0.0	2.71	0.0

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	<u>S. ingrassata</u>		3.30	0.0	3.30	0.0
	<u>Themeda triandra</u>		2.29	0.0	3.10	0.0
	DECREASER TOTAL	14.7		48.4		7.8
INCREASER	<u>Hyparrhenia filipendula</u>		3.09	0.0	4.92	0.0
SPECIES	<u>Hyperthelia dissoluta</u>		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	<u>Aristida barbicollis</u>	20.40	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	<u>Bothriochloa radicans</u>	6.50	-0.77	-5.0	2.96	19.2
	<u>Enneapogon cenchroides</u>	1.80	0.00		0.00	
	<u>Eragrostis rigidior</u>	4.70	-3.13	-14.7	-2.76	-13.0
	Forbs	16.90	-0.01	-0.2	4.09	-69.1
	<u>Heteropogon contortus</u>	0.20	0.00		0.00	
	<u>Pogonarthria squarrosa</u>	1.70	-1.48	-2.5	-0.92	-1.6
	<u>Schmidtia pappophoroides</u>	2.40	0.07	0.2	-1.50	-3.6
	<u>Tragus berteronianus</u>	0.30	-3.11	-0.9	-4.72	-1.4
	<u>Urochloa mosambicensis</u>	0.10	0.00		0.00	
				268.0		389.0
	INCREASER II TOTAL	55.0		-23.2		-69.4
	OTHERS	30.3	TOTAL	293.2		327.4
	TOTAL	100.0				

		Percent	Utilisation
TREND:	Decreaser species	14.7	Moderate
	Increaser I species	0.0	Under
	Increaser II species	55.0	Over * Habitat Type 5 Rating

<u>KLASERIE HABITAT TYPE 6</u>

			1988		1987	
		FREQUENCY	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	<u>Cenchrus ciliaris</u>		1.59	0.0	2.16	0.0
SPECIES	<u>Digitaria eriantha</u>	6.90	1.30	9.0	0.00	
	<u>Panicum coloratum</u>		4.25	0.0	2.90	0.0
	<u>Panicum maximum</u>	2.20	7.40	16.3	1.63	3.6

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	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0
	Themeda triandra	0.70	2.29	1.6	3.10	2.2
	DECREASER TOTAL	9.8		26.9		5.8
INCREAS.	*Hyparrhenia filipendula*		3.09	0.0	4.92	0.0
SPECIES	*Hyparrhenia dissoluta*		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.00		0.0		0.0
INCREAS.	*Aristida barbicollis*	23.00	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	*Bothriochloa radic*	6.90	-0.77	-5.3	2.96	20.4
	Enneapogon cenchroides	3.50	0.00		0.00	
	Eragrostis rigidior	7.10	-3.13	-22.2	-2.76	-19.6
	Forbs	29.10	-1.01	-0.3	-4.09	-119.0
	Heteropogon contortus	0.20	0.00		0.00	
	Pogonarthria squarrosa	3.50	-1.48	-5.2	-0.92	-3.2
	Schmidtia pappophoroides	2.90	0.07	0.2	-1.50	-4.4
	Tragus berteronianus	0.30	-3.11	-0.9	-4.72	-1.4
	Urochloa mosambicensis		0.00		0.00	
				268.0		389.0
	INCREASER II TOTAL	76.5		-33.7		-127.2
	OTHERS	13.7	TOTAL	261.1		267.6
	TOTAL	100.0				

		Percent	Utilisation.
TREND:	Decreaser species	9.8	Moderate
	Increaser I species	0.0	Under
	Increaser II species	76.5	Over * Habitat Type 6 Rating

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KLASERIE HABITAT TYPE 7

			1988		1987	
		FREQ.	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	Cenchrus ciliaris		1.59	0.0	2.16	0.0
SPECIES	Digitaria eriantha	16.30	1.30	21.2	0.00	
	Panicum coloratum		4.25	0.0	2.90	0.0
	Panicum maximum	4.80	7.40	35.5	1.63	7.8
	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0
	Themeda triandra	2.40	2.29	5.5	3.10	7.4
	DECREASER TOTAL	23.5		62.2		15.3
INCREAS.	Hyparrhenia filipendula		3.09	0.0	4.92	0.0
SPECIES	Hyperparrhenia dissoluta		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	Aristida spp.		6.60	0.00		0.00
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II						
	Bothriochloa radicans	9.40	-0.77	-7.2	2.96	27.8
	Enneapogon cenchroides	0.50	0.00		0.00	
	Eragrostis rigidior	5.40	-3.13	-16.9	-2.76	-14.9
	Forbs	14.50	-0.01	-0.1	-4.09	-59.3
	Heteropogon contortus	3.20	0.00		0.00	
	Pogonarthria squarrosa	0.70	-1.48	-1.0	-0.92	-0.6
	Schmidtia pappophoroides	6.60	0.07	0.5	-1.50	-9.9
	Tragus berteronianus	1.90	-3.11	-5.9	-4.72	-9.0
	Urochloa mosambicensis		0.00		0.00	
			268.0		389.0	
	INCREASER II TOTAL	58.8		-30.8		-65.9
	OTHERS	17.7	TOTAL	299.4		338.4
	TOTAL 100.0					

		Percent	Utilisation
TREND:	Decreaser species	23.5	Moderate

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Increaser I species	0.0	Under	
Increaser II species	58.8	Over *	Habitat Type 7 (A Transect)

Rating

KLASERIE HABITAT TYPE 7

			1988		1987	
		FREQ.	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	Cenchrus ciliaris		1.59	0.0	2.16	0.0
SPECIES	Digitaria eriantha	12.60	1.30	16.4	0.00	
	Panicum coloratum		4.25	0.0	2.90	0.0
	Panicum maximum	2.40	7.40	17.8	1.63	3.9
	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0
	Themeda triandra		2.29	0.0	3.10	0.0
	DECREASER TOTAL	15.0		34.1		3.9
INCREAS.	Hyparrhenia filipendula		3.09	0.0	4.92	0.0
SPECIES	Hyperparrhenia dissoluta		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	Aristida spp.	17.70	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	Bothriochloa radicans	1.50	-0.77	-1.2	2.96	4.4
	Enneapogon cenchroides	0.40	0.00		0.00	
	Eragrostis rigidior	5.50	-3.13	-17.2	-2.76	-15.2
	Forbs	38.00	-0.01	-0.4	-4.09	-155.4
	Heteropogon contortus		0.00		0.00	
	Pogonarthria squarrosa	2.40	-1.48	-3.6	-0.92	-2.2
	Schmidtia pappophoroides	1.07	0.07	0.1	-1.50	-1.6
	Tragus berteronianus	1.30	-3.11	-4.0	-4.72	-6.1
	Urochloa mosambicensis		0.00		0.00	
				268.0		389.0
	INCREASER II TOTAL	67.9		-26.3		-176.1
	OTHERS	17.1	TOTAL	275.9		216.8

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TOTAL 100.0

		Percent	Utilisation
TREND:	Decreaser species	15.0	Moderate
	Increaser I species	0.0	Under
	Increaser II species	67.9	Over * Habitat Type 7 (B Transect) Rating

KLASERIE HABITAT TYPE 8

			1988		1987	
		FREQ.	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	*Cenchrus ciliaris*		1.59	0.0	2.16	0.0
SPECIES	*Digitaria eriantha*	10.40	1.3	13.5	0.00	
		4.25	0.0	2.90	0.0	
	Panicum maximum	4.20	7.40	31.1	1.63	6.8
	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0
	Themeda triandra	2.10	2.29	4.8	3.10	6.5
	DECREASER TOTAL	16.7		49.4		13.4
INCREAS.	*Hyparrhenia filipendula*		3.09	0.0	4.92	0.0
SPECIES	*Hyperparrhenia dissoluta*		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	*Aristida* spp.	17.90	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	*Bothriochloa radicans*	3.10	-0.77	-2.4	2.96	9.2
	Enneapogon cenchroides	0.70	0.00		0.00	
	Eragrostis rigidior	10.00	-3.13	-31.3	-2.76	-27.6
	Forbs	19.70	-0.01	-0.2	-4.09	-80.6
	Heteropogon contortus	0.10	0.00		0.00	
	Pogonarthria squarrosa	5.50	-1.48	-8.1	-0.92	-5.1
	Schmidtia pappophoroides	4.60	0.07	0.3	-1.50	-6.9
	Tragus Berteronianus		-3.11	0.0	-4.72	0.0
	Urochloa mosambicensis	0.30	0.00		0.00	
				268.0		389.0
	INCREASER II TOTAL	61.9		-41.7		-111.0

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OTHERS	21.4	TOTAL	275.7	291.4
TOTAL 100.0				

		Percent	Utilisation
TREND:	Decreaser species	16.7	Moderate
	Increaser I species	0.0	Under
	Increaser II species	61.9	Over * Habitat Type 8 Rating

KLASERIE HABITAT TYPE 9

			1988		1987	
		FREQ.	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	*Cenchrus ciliaris*		1.59	0.0	2.16	0.0
SPECIES	*Digitaria eriantha*	1.50	1.30	2.0	0.00	0.0
	Panicum coloratum		4.25	0.0	2.90	0.0
	Panicum maximum	3.90	7.40	28.9	1.63	6.4
	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0
	Themeda triandra		2.29	0.0	3.10	0.0
	DECREASER TOTAL	5.4		30.8		6.4
INCREAS.	*Hyparrhenia filipendula*		3.09	0.0	4.92	0.0
SPECIES	*Hyperparrhenia dissoluta*		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	*Aristida barbicollis*	22.80	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	*Bothriochloa radicans*	2.80	-0.77	-2.2	2.96	8.3
	Enneapogon cenchroides	1.70	0.00		0.00	0.0
	Eragrostis rigidior	6.30	-3.13	-19.7	-2.76	-17.4
	Forbs	34.10	-0.01	-0.3	-4.09	-139.5
	Heteropogon contortus	0.60	0.00		0.00	0.0
	Pogonarthria squarrosa	1.00	-1.48	-1.5	-0.92	-0.9
	Schmidtia pappophoroides	9.00	0.07	0.6	-1.50	-13.5
	Tragus berteronianus	0.30	-3.11	-0.9	-4.72	-1.4
	Tragus berteronianus		0.00		0.00	0.0
				268.0		389.0

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	INCREASER II TOTAL	78.6		244.0		224.6
	OTHERS	16.0	TOTAL	274.8		231.0
	TOTAL 100.0					

		Percent	Utilisation
TREND:	Decreaser species	5.4	Moderate
	Increaser I species	0.0	Under
	Increaser II species	78.6	Over * Habitat Type 9 Rating

KLASERIE HABITAT TYPE 10

			1988		1987	
		FREQ.	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	*Cenchrus ciliaris*		1.59	0.0	2.16	0.0
SPECIES	*Digitaria eriantha*	4.50	1.30	5.9	0.00	
	Panicum coloratum	1.40	4.25	6.0	2.90	4.1
	Panicum maximum	3.20	7.40	23.7	1.63	5.2
	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0
	Themeda triandra		2.29	0.0	3.10	0.0
	DECREASER TOTAL	9.1		35.5		9.3
INCREAS.	*Hyparrhenia filipendula*		3.09	0.0	4.92	0.0
SPECIES	*Hyparrhenia dissoluta*		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	*Aristida* spp.	11.10	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	*Bothriochloa radicans*	17.80	-0.77	-13.7	2.96	52.7
	Enneapogon cenchroides	0.20	0.00		0.00	
	Eragrostis rigidior	4.60	-3.13	-14.4	-2.76	-12.7
	Forbs	24.50	-0.01	-0.2	-4.09	-100.2
	Heteropogon contortus	0.20	0.00		0.00	
	Pogonarthria squarrosa	1.80	-1.48	-2.7	-0.92	-1.7
	Schmidtia pappophoroides	0.20	0.07	0.0	-1.50	-0.3
	Tragus berteronianus	0.90	-3.11	-2.8	-4.72	-4.2
	Urochloa mosambicensis	2.30	0.00		0.00	

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				268.0		389.0
	INCREASER II TOTAL	63.6		-33.8		-66.4
	OTHERS	27.3	TOTAL	269.7		331.9
	TOTAL 100.0					

		Percent	Utilisation
TREND:	Decreaser species	9.1	Moderate
	Increaser I species	0.0	Under
	Increaser II species	**63.6**	Over * Habitat Type 10 Rating

KLASERIE HABITAT TYPE 11a

			1988		1987	
		FREQ.	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	Cenchrus ciliaris		1.59	0.0	2.16	0.0
SPECIES	Digitaria eriantha	5.00	1.30	6.5	0.00	
	Panicum coloratum	2.30	4.25	9.8	2.90	6.7
	Panicum maximum	14.60	7.40	108.0	1.63	23.8
	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0
	Themeda triandra		2.29	0.0	3.10	0.0
	DECREASER TOTAL	21.9		124.3		30.5
INCREAS.	Hyparrhenia filipendula		3.09	0.0	4.92	0.0
SPECIES	Hyperparrhenia dissoluta		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	Aristida barbicollis	8.10	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	Bothriochloa radican	25.00	-0.77	-19.3	2.96	74.0
	Enneapogon cenchroides	0.50	0.00		0.00	
	Eragrostis rigidior	12.60	-3.13	-39.4	-2.76	-34.8
	Forbs	7.90	-0.01	-0.1	-4.09	-32.3
	Heteropogon contortus		0.00		0.00	
	Pogonarthria squarrosa		-1.48	0.0	-0.92	0.0

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<u>Schmidtia pappophoroides</u>	0.50	0.07	0.0	-1.50	-0.8
<u>Tragus berteronianus</u>	0.20	-3.11	-0.6	-4.72	-0.9
<u>Urochloa mosambicensis</u>		0.00		0.00	
			268.0		389.0
INCREASER II TOTAL	54.8		-59.4		5.2
OTHERS	23.3	TOTAL	333.0		424.7
TOTAL	100.0				

		Percent	Utilisation
TREND:	Decreaser species	21.9	Moderate
	Increaser I species	0.0	Under
	Increaser II species	54.8	Over * Habitat Type 11a Rating

<u>KLASERIE HABITAT TYPE 11b</u>

			1988		1987	
		FREQ.	FACTOR	SCORE	FACTOR	SCORE
	<u>Panicum maximum</u>	6.30	7.40	46.6	1.63	10.3
	<u>Setaria flabellata</u>		2.52	0.0	2.71	0.0
	<u>S. ingrassata</u>		3.30	0.0	3.30	0.0
	<u>Themeda triandra</u>	0.90	2.29	2.1	3.10	2.8
	DECREASER TOTAL	19.9		77.6		25.2
INCREAS.	<u>Hyparrhenia filipendula</u>		3.09	0.0	4.92	0.0
SPECIES	<u>Hyperparrhenia dissoluta</u>		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	<u>Aristida</u> spp.	12.30	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	<u>Bothriochloa radicans</u>	7.40	-0.77	-5.7	2.96	21.9
	<u>Enneapogon cenchroides</u>	0.30	0.00		0.00	
	<u>Eragrostis rigidior</u>	3.60	-3.13	-11.3	-2.76	-9.9
	Forbs	15.50	-0.01	-0.2	-4.09	-63.4
	<u>Heteropogon contortus</u>		0.00		0.00	
	<u>Pogonarthria squarrosa</u>	1.00	-1.48	-1.5	-0.92	-0.9
	<u>Schmidtia pappophoroides</u>	0.40	0.07	0.0	-1.50	-0.6
	<u>Tragus berteronianus</u>	0.10	-3.11	-0.3	-4.72	-0.5

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	Urochloa mosambicensis	0.20	0.00		0.00	
				268.0		389.0
	INCREASER II TOTAL	40.8		-18.9		-53.4
	OTHERS	39.3	TOTAL	326.7		360.8
	TOTAL	100.0				

		Percent.	Utilisation
TREND:	Decreaser species	19.9	Moderate
	Increaser I species	0.0	Under
	Increaser II species	40.8	Over * Habitat Type 11b Rating

KLASERIE HABITAT TYPE 12

			1988		1987	
		FREQ.	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	Cenchrus ciliaris		1.59	0.0	2.16	0.0
SPECIES	Digitaria eriantha	14.50	1.30	18.9	0.00	
	Panicum coloratum		4.25	0.0	2.90	0.0
	Panicum maximum	4.70	7.40	34.8	1.63	7.7
	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0
	Themeda triandra		2.29	0.0	3.10	0.0
	DECREASER TOTAL	19.2		53.6		7.7
INCREAS.	Hyparrhenia filipendula		3.09	0.0	4.92	0.0
SPECIES	Hyperparrhenia dissoluta		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	Aristida spp.	8.90	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	Bothriochloa radicans	5.80	-0.77	-4.5	2.96	17.2
	Enneapogon cenchroides	2.60	0.00		0.00	
	Eragrostis rigidior	8.40	-3.13	-26.3	-2.76	-23.2
	Forbs	25.70	-0.01	-0.3	-4.09	-105.1
	Heteropogon contortus		0.00		0.00	
	Pogonarthria squarrosa	4.10	-1.48	-6.1	-0.92	-3.8

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	Schmidtia pappophoroides	5.30	0.07	0.4	-1.50	-8.0
	Tragus berteronianus	0.30	-3.11	-0.9	-4.72	-1.4
	Urochloa mosambicensis		0.00		0.00	
				268.0		389.0
	INCREASER II TOTAL	61.1		-37.6		-124.3
	OTHERS	19.7	TOTAL	284.0		272.4
	TOTAL					

		Percent	Utilisation
TREND:	Decreaser species	19.2	Moderate
	Increaser I species	0.0	Under
	Increaser II species	61.1	Over * Habitat Type 12 Rating

KLASERIE HABITAT TYPE 13

			1988		1987	
		FREQ.	FACTOR	SCORE	FACTOR	SCORE
DECREAS.	Cenchrus ciliaris		1.59	0.0	2.16	0.0
SPECIES	Digitaria eriantha	2.80	1.30	3.6	0.00	
	Panicum coloratum		4.25	0.0	2.90	0.0
	Panicum maximum	4.00	7.40	29.6	1.63	6.5
	Setaria flabellata		2.52	0.0	2.71	0.0
	S. ingrassata		3.30	0.0	3.30	0.0
	Themeda triandra	2.50	2.29	5.7	3.10	7.8
	DECREASER TOTAL	9.3		39.0		14.3
INCREAS.	Hyparrhenia filipendula		3.09	0.0	4.92	0.0
SPECIES	Hyperparrhenia dissoluta		1.36	0.0	6.94	0.0
I	INCREASER I TOTAL	0.0		0.0		0.0
INCREAS.	Aristida spp.	22.80	0.00		0.00	
SPECIES	Bare ground		-3.11	0.0	-4.72	0.0
II	Bothriochloa radicans	2.90	-0.77	-2.2	2.96	8.6
	Enneapogon cenchroides	2.50	0.00		0.00	
	Eragrostis rigidior	6.70	-3.13	-21.0	-2.76	-18.5
	Forbs	12.30	-0.01	-0.1	-4.09	-50.3

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Heteropogon contortus	1.60	0.00		0.00	
Pogonarthria squarrosa	2.70	-1.48	-4.0	-0.92	-2.5
Schmidtia pappophoroides	10.90	0.07	0.8	-1.50	-16.4
Tragus berteronianus	0.20	-3.11	-0.6	-4.72	-0.9
Urochloa mosambicensis	0.80	0.00		0.00	
			268.0		389.0
INCREASER II TOTAL	63.4		-27.2		-80.0
OTHERS	27.3	TOTAL	279.8		323.3
TOTAL					

		Percent	Utilisation
TREND:	Decreaser species	9.3	Moderate
	Increaser I species	0.0	Under
	Increaser II species	63.4	Over * Habitat Type 13 Rating

SUMMARY: Appendix A

HABITAT AREA	FORAGE RATING	FUEL RATING	UTILISATION CLASS	STANDING CROP Kg/ha	
2	LOW	LOW	OVER	1245	
4	MEDIUM	LOW	OVER	1148	
5	LOW	MEDIUM	OVER	1540	
6	LOW	LOW	OVER	1530	
7	MEDIUM	MEDIUM	OVER	1550	MOPANE
7	LOW	LOW	OVER	1396	COMBRETUM
8	LOW	LOW	OVER	1329	
9	LOW	LOW	OVER	1633	
10	LOW	MEDIUM	OVER	922	
11a	MEDIUM	HIGH	MEDIUM	1148	
11b	MEDIUM	MEDIUM	MEDIUM	1752	
12	LOW	LOW	OVER	1337	
13	LOW	MEDIUM	OVER	2364	

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<u>COMPARISON</u>:

May 1988 survey data contrasted with June 1987 survey:

HABITAT TYPE	DECREASER	SPECIES	INCREASER	SPECIES I	INCREASER	SPECIES II
	1987	1988	1987	1988	1987	1988
1	8	*	3.3	*	88.8	*
2	17.5	29.6	1.2	6.1	81.7	64.3
3	37.6	*		*	62.4	*
4	38.1	31.8	2.1	3.9	60.1	64.3
5	27	34.2		4.4	72.3	61.5
6	14.1	17.6	6.8	1.3	79.1	80.9
7	37.7	38.1		3.6	62.3	58.1
8	20.6	28.9		1.6	79.4	69.4
9	7.8	19	0.6		91.6	74.1
10	10.5	26.4		1.9	89.5	71.7
11	35.6	51.9	1.2	0.8	63.2	47.6
12	23.6	32	4.4	2.7	72	65.1
13	23.6	40.3	2.2	2.1	74.2	57.6

* NOT SURVEYED

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