IMPACT OF ELEPHANT INDUCED VEGETATION CHANGE ON THE STATUS OF THE BUSHBUCK (*TRAGELAPHUS SCRIPTUS ORNATUS*) ALONG THE CHOBE RIVER IN NORTHERN BOTSWANA.

JOANNE ESTELLE ADDY

A Dissertation Submitted to the Faculty of Science
University of the Witwatersrand, Johannesburg
for the degree of Master of Science.

Johannesburg 1993

ABSTRACT

This study was carried out along the Chobe river front region in Northern Botswana. Bushbuck numbers had reportedly declined along the river front (Gibson 1990). The decline was probably related to the vegetation change which had occurred due to the heavy utilisation by elephant. The aims of this study were:

(1) to estimate the extent of the decline in the bushbuck population along the Chobe river front since 1969/1970; and

(2) to determine the relation between the elephant induced vegetation change and the current status of the bushbuck population.

Bushbuck abundance and distribution were assessed by road and river counts and identification of known individuals. The results obtained from my study were compared with the results from a previous study in 1969/1970. The general study area (GSA) extended from the Park headquarters to Ihaha. Within the GSA a smaller intensive study area (ISA), situated between Crocodile island and Ihaha was delimited.

The study confirmed a decline in the bushbuck population over the 21 years. This decline appears to have been spatially variable along the river frontage. There were pockets where suitable habitats persisted and where the population had declined to about 34% (between 24% and 43%) of the 1969/70 level. They included the intensive study area where bushbuck had been abundant historically. The extent of the decline had been more severe in the section of the GSA outside the ISA. In these areas the bushbuck numbers had dropped to only 2% of the former level.

The adult sex ratio was biased towards females, as found in other studies. The incidence of juvenile sightings increased in October and November. The known individuals showed that there was no lack of breeding success in the ISA.

Vegetation types included riparian fringe woodland, *Acacia* woodland, *Croton-Capparis* shrubland, *Combretum-Baphia* shrubland, *Combretum-Dichrostachys* thicket and mixed ecotone. The *Croton-Capparis* shrubland was not recognised in 1969/1970. The vegetation change was most evident by the loss of tall trees. Dead *Acacia tortilis, Acacia erioloba* and *Berchemia discolor* were scattered throughout the *Acacia* woodland.

Bushbuck preferred the riparian fringe woodland and *Croton-Capparis* shrubland during the dry season months July to September. *Combretum-Baphia* shrubland became the favoured vegetation type in October at the end of the dry season. The *Acacia* woodland was relatively little used from July to October. By November bushbuck showed a relatively even use of the vegetation types.

Bushbuck were frequently associated with the shrub *Capparis tomentosa*. They were seen feeding on its leaves and at the base of the clumps which supported a variety of grasses, forbs and saplings. The dome shaped clumps were frequently used for concealment during the day.

Bushbuck preferred sites which had low lateral visibility and total canopy cover when they were resting (which included standing and lying). Rumination took place when bushbuck were resting. When feeding or walking bushbuck preferred sites where canopy cover and lateral visibility were low.

DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before any degree or examination in any other University.

____

2nd day of March, 1993

TO DAD, MOM AND CHIMANIMANI

" MAN IS NOT THE CREATURE OF CIRCUMSTANCES,
CIRCUMSTANCES ARE THE CREATURES OF MAN "

DISRAELI

PREFACE

In a world where conflict and violence abound Botswana is a refreshing and intriguing country. The charisma and generosity of the people, the wealth of its wildlife and ecological features are all part of the magnetism that Botswana has to offer. Botswana to its credit has set aside as much as 47% of its land for wildlife in one form or another. Game reserves and National Parks account for 17% of the land.

Many problems face developing countries, difficult desisions have to be made for the well-being of the people and the natural resources. The Department of Wildlife and National Parks has taken a positive approach by encouraging research to aid in future management decisions concerning Botswana's wildlife.

After growing up in Botswana, mere words are not enough to express the delight and privilege I felt when given the opportunity to work and live in Chobe National Park. I cannot thank enough all those people who made my dream possible. I am most grateful to Professor Norman Owen-Smith for including me among his team of ecologists working in Botswana, and the Department of Wildlife and National Parks for giving me the opportunity to work in such a special environment.

I am extremely grateful to Jonathon Gibson, The Chobe Game Lodge and the Chobe Wildlife Trust for sponsoring the project. To everyone at Chobe Game Lodge; Jonathon, Ronell, Mike, Chimani, Terry, Bonny, Helge, Jill, Mike and all the staff, thank-you so much. Watching Chimani grow up from a tiny vulnerable lamb into a majestic sub-adult bushbuck, "Albert the sleeping elephant" and the "Phantom Bakky thief" are only a few of the unforgettable occasions we shared; Thank-You.

I am indebted to Mark Vandewalle for his encouragement and advice as well as the nickname "The Bushbuck Lady", which I can't seem to shake off. I am extremely grateful to Heather Carr-Hartley of Kasane Enterprises for all her help. Thanks also go to Debby Eperson and Willy Logoloba who assisted me in the field. I am grateful to Grant and Marie at Liunshulu for their kind hospitality. To all the various friends in Kasane who were involved in the success of the project in one way or another thank-you. To those friends who willingly gave me lifts to and from Kasane I am very grateful. I am indebted to Professor Norman Owen-Smith for his advice and time that he dedicated to this project as well as reading various chapters and drafts. I cannot express my gratitude enough to Jean and Llew Drew who opened their home to me in Johannesburg. They gave me moral support and encouragement during the study and made it possible for one of my dreams to come true.

Finally and in no ways the least, I want to thank my Dad, Mom, Helen and Nicola for their unbounded love, support and enthusiasm. For all their encouragement for me to pursue my career in wildlife ecology and to follow my dreams, Thank-You.

Financial assistance was supplied by Chobe Game Lodge, The Chobe Wildlife trust and the University of Witwatersrand Senior Bursary. To all those people who I have mentioned or unintentially forgotton, Thank-You for making this project possible.

LIST OF ABBREVIATIONS

°	degree(s)
'	minute(s)
cm	centimetre(s)
m	metre(s)
ha	hectare(s)
km	kilometre(s)
h	hour(s)
N	sample size
pers.obs.	personal observation
et al .	and colleagues
i.e.	that is
χ^2	chi-sguared
ISA	Intensive study area
GSA	General study area

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

1.0: INTRODUCTION

1.1 BACKGROUND

There are many aspects to conservation, one of the most important being the continued protection of natural ecosystems from interference by man to serve as ecological baselines. Other facets include the preservation of rare species, their habitats and the maintenance of genetic diversity.

As the elephant numbers in Northern Botswana increase (Melton 1985, Work 1986, Craig 1990, Calef 1991a) an understanding of what consequences the elephant induced vegetation changes are having on other animal species is required. By opening up the woody and herbaceous cover, elephants alter the habitat conditions for other species. Species which favour these open habitats (roan antelope and tsessebe) may benefit from such changes, whilst others dependent on dense cover such as the bushbuck may suffer.

Concern has been expressed about a marked decline in the bushbuck numbers and distribution along the Chobe river front (Gibson 1991). Unless there are areas where suitable habitats persist despite the impact of elephant, the Chobe bushbuck (*Tragelaphus scriptus ornatus*) could disappear from this region. The Chobe river area is of specific importance in that it protects the only population of bushbuck within the present Chobe National Park boundaries. This study was planned to estimate the decline of the bushbuck and determine the effects of the elephant induced vegetation change on their habitat choice.

1.2 OBJECTIVES

The objectives of the study were:-

(A) to estimate the extent of the decline in the bushbuck population along the Chobe river front since 1969/1970, and

(B) to determine the relation between the elephant induced vegetation change and the current status of the bushbuck population.

To meet these objectives the following questions were posed:-

(a) What is the present abundance of the bushbuck ?
(b) What is the present distribution of the bushbuck ?
(c) How severe has the decline been ?
(d) How has the vegetation changed since 1969-1970 ?
(f) What vegetation types are preferred by the bushbuck ?
(g) What vegetation features are important for the persistence of bushbuck ?

1.3 LITERATURE REVIEW

1.3.1 Taxonomy of the bushbuck

The bushbuck (*Tragelaphus scriptus* pallas) is a widely distributed and highly adaptable species which occurs throughout Africa from the Sahel to the Southern Cape. Twenty three sub-species were recognised by Haltenorth (1963; cited in Smithers 1990) but this was later revised by Ansell (1972; cited in Smithers 1990) to 9 sub-species. The 3 sub-species which occur in southern Africa include *Tragelaphus scriptus ornatus* (Pocock 1900), *Tragelaphus scriptus roualeyni* (Gray 1852) and *Tragelaphus scriptus sylvaticus* (Sparrman 1780).

The Chobe bushbuck is of the sub-species *Tragelaphus scriptus ornatus* which extends throughout the Zambezi valley drainage from Angola to Mozambique and from the Southern Congo to the Zimbabwe watershed (Simpson 1974). The distribution of *Tragelaphus scriptus roualeyni* is limited to the Limpopo drainage, occurring in southern Botswana, southern Zimbabwe and southern Mozambique. *Tragelaphus scriptus sylvaticus* occurs in the Transvaal, Natal and southern Cape in South Africa (Smithers 1983).

Tragelaphus scriptus ornatus is more colourful than the other 2 sub-species. The characteristic pattern of white lines and spots on the body along with the white patch on the throat and the white crescent on the lower neck contrast noticeably with the rich red colouration of males and females. In males a dark collar at the base of the neck stands out prominently against the dark red coat.

1.3.2 Decline in bushbuck along the Chobe river

"Most of our wildlife systems are inherently unstable in the sense of persistence and they have been that way for hundreds of years. In any one year, one or more of the species in the system will be on the path declining towards extinction, but the conditions for that do not usually last long enough. The environment changes and those endangered species recover, only to be replaced by some other species that is now in decline. Constant change in the relative favouring of different species in the system enables all of them to persist for a long time" (B.H Walker 1986 quoted by Levin 1986).

As our understanding of the population dynamics of animal populations increases it is becoming progressively clearer that the suitability of the habitat and its role in determining the trends of the associated animal populations is of fundamental importance. The weakened performance of a population can become apparent by the animals losing condition, becoming more susceptible to predators, reducing their reproductive rates and/or showing higher mortality rates or in a combination of all these factors (Geist 1971).

In southern Africa bushbuck have been known to persist in areas close to human settlement long after other ungulates have gone. This is largely due to the secretive, inconspicuous behaviour of the bushbuck (Simpson 1974). Bushbuck decline in other localised areas has been attributed to the disturbance of their habitats (Grimwood 1958; Du Plessis 1969 cited by Allen-Rowlandson 1986). Interspecific competition with Nyala (*Tragelaphus angasii*) has been suggested as a probable factor in the decline of bushbuck in Hluhluwe and Umfolozi game reserves in South Africa (Anderson 1979).

Child (1968) reports bushbuck being common along the Chobe and Linyanti rivers, but less common in the Okavango delta. He concluded that the bushbuck population (between the park headquarters and Ihaha) in 1965 was probably at a peak in numbers and also expressed concern that food could become a limiting factor due to the greater riverside utilisation from increasing elephant and buffalo herds. Child (1968) reported that old residents of Kasane were in agreement that bushbuck were more common along the river in 1965 than during the previous 10 year period.

In 1969-1970 Simpson (1974) stated that the bushbuck population along the Chobe river was at approximately the same level as in 1965. He also suggested that at the turn of the century, habitats were relatively open and bushbuck were more than likely to have been confined to the riparian forest fringe along the river. Thickets developed once the pastoralists moved out and burning decreased. This would have enabled bushbuck to expand their distribution further south away from the river (Simpson 1974). Simpson's results were similar to Child's and this led him to conclude that " bushbuck numbers appear to have stabilised over the past 5 years (1965 to 1970)", but he stressed that "they cannot maintain themselves in the face of progressive habitat deterioration".

Most earlier published accounts report that bushbuck are primarily browsers but on occasions they have been observed grazing (Wilson & Child 1964; Hofman 1973, cited in Smithers 1990). Feeding studies have shown that leaves form the main food component, followed by flowers, then pods and fruit and finally buds and shoots (Jacobsen 1974; Simpson 1974).

1.3.3 Vegetation changes along the Chobe river front

1.3.2.1 Land use history

Past land use. mainly the livestock and logging industries, plus too frequent burning early in the season and the high concentrations of elephants have altered the vegetation along the Chobe river from its original state (Child 1968). With the proclamation to National Park status in 1966 a non burning policy was immediately undertaken and is still in effect today. However the adjacent land users adopt burning policies which affect the park, as fires spread into the park.

Child (1968) reported that "Past and present burning practices have undoubtedly had a very marked and widespread effect on the habitats of north-east Botswana. They have altered the composition of the plant communities and this is reflected by the changing trends in the animal populations".

Around 1925 the vegetation surrounding the cattle posts at Serondella had begun to change as a result of burning and overgrazing of the area. Woody shrubs encroached the area and *Dichrostachys cinerea* flourished and became widespread, offering an ideal habitat for the tsetse fly (Child 1968). Tsetse flies are the host of the disease Nagana in cattle and sleeping sickness (trypanosomiasis) in man. By the 1950's the local tribesmen and their cattle were forced to move south and evacuate this area (Potten 1975).

From 1936 - 1955 the logging industry thrived in the Chobe district. In 1936 a sawmill was established at Lesuma, just east of the park. The Chobe Timber concession of 1944 - 1955 extended from Serondella west towards Ngoma. The commercially valuable species *Pterocarpus angolensis* was heavily exploited. Additional sawmills were built, a large one at Serondella and a smaller one at Ihaha. The ruins of these buildings still remain around Serondella and Ihaha. With the cessation of the timber contracts by the 1960's the Chobe area south of the river came under the forestry department authority and they encouraged protection of wildlife in this area (Potten 1975; Campbell 1976; Tlou 1976).

1.3.2.2 Vegetation history along the Chobe river

The major timber trees of the Chobe district are described by Miller and Kelly-Edwards (1960) and later by Henry (1966). Child (1965) classified the vegetation along the Chobe river front in 1965 into riparian forest fringe, floodplain grassland and Kalahari sandveld. The thin riparian fringe did not exceed 70 metres (Child 1968). The Kalahari sandveld vegetation situated along the north face of the sand ridge was described by Selous (1881 quoted by Child 1968) as being "dense jungle", where visibility was restricted to a few metres. Child (1968) reported that by 1965 the vegetation along the north face of the sand ridge was more open. Simpson (1974) carried out a more detailed study of the vegetation in an intensive study area along the Chobe river between "Crocodile island" and "rhino pens". He distinguished eight vegetation types along the Chobe river between Park headquarters and Ihaha. They comprised the following:

(i) floodplain grassland,
(ii) riparian forest fringe,
(iii) riverine *Acacia* tree savanna,
(iv) regrowth *Combretum-Baphia* scrub,
(v) *Dichrostachys* thicket,

(vi) *Baikiaea plurijuga* woodland,

(vii) mixed tree/bush ecotone and

(viii) *Colophospermum mopane* tree/bush savanna.

Somerlatte (1976) stated that the *Acacia* canopy had opened up and was comprised of younger trees. He classified the riverine *Acacia* tree savanna as *Acacia* woodland. In 1985 Moroka describes the Chobe river front woodland (classified as *Acacia* woodland by Sommerlatte 1976) as a narrow strip of about two kilometres wide between park headquarters and Serondella. He stated that" the most dominant tree species was *Dichrostachys cinerea*".

1.3.2.3 Influence of wildlife on vegetation

Since about the mid 1950's elephant numbers in northern Botswana have increased (Spinage 1990). The elephant population appears to be increasing at maximum population growth rate (Calef 1989). The high densities of elephant around dry season watering points have been reported to cause a detrimental effect to the woody vegetation (Child 1968; Sommerlatte 1974; Work 1985; Moroka 1986). Elephant account for over 60 % of the large herbivore biomass in the Chobe region (Melton 1983). During the dry season months, April to October, a 50 km stretch along the Chobe river supports a high concentration of elephant. The Chobe and Linyanti rivers are the only perennial sources of water at the height of the dry season.

Aerial surveys show that the dry season elephant densities along the Chobe river front range from 3.2 to 7 km^{-2} (Melton 1985; Work 1986; Craig 1990, Calef 1991). Wet season elephant densities along the Chobe river were estimated to be 1 km^{-2} or less (Work 1986; Craig 1990; Calef 1991). It is during the dry season that the vegetation is subjected to short term, high intensity utilisation (Child 1968; Sommerlatte 1976).

Child (1968) recommended that a significant reduction in numbers of elephant along the Chobe river should be carried out to relieve the pressure on the vegetation on the face of the sand ridge and the riparian fringe communities (Child 1968). The issue of culling has been subsequently raised by other researchers (Sommerlatte 1976; Moroka 1985; Melton 1986; Work 1986).

Simpson (1975) reported that there had been a shift in the order of plant dominance and an increase in the amount of damage to plants over the five years (1965 to 1970). In areas where utilisation was heaviest *Baphia massaiensis* was the most common species with *Combretum elaeagnoides* the second most common species, a reversal of the 1965 situation (Simpson 1975).

In areas where the vegetation change was at a less advanced stage *Combretum elaeagnoides* remained the most dominant species followed by *Baphia massaiensis*. Two species *Markhamia acuminata* and *Combretum mossambicense*, which had not previously been recorded, were present in 1970. These plant species have been reported to be invaders of damaged and over-utilised areas (Simpson 1974). By 1970 the vegetation change in the riparian forest fringe and the riverine habitats was evident (Simpson 1974a). Simpson stressed that with the continued vegetation alteration, many smaller wildlife species associated with these two habitats could become threatened.

Sommerlatte (1976) advised that a 30 % reduction in elephant numbers should be undertaken to alleviate the pressure on the riverine vegetation. He found that elephant induced mortality to mature trees was most severe in the *Acacia* community along the river and indicated that there was a serious lack of regeneration in the *Acacia* stands (Sommerlatte 1976). *Acacia* trees are easily pushed over by elephant (Lamprey et al 1967). In 1984 Moroka found that elephant related damage was highest on the *Acacia* species along the river and implied that the decline in these species had been concomitant with the increase in elephant numbers.

1.3.2.4 Habitat needs of the bushbuck

Most reports of habitat preference and requirements stress the importance of dense riparian and thicket vegetation to the bushbuck. The favoured habitats are riparian forest fringe (Child 1968; Simpson 1974c), riverine *Acacia* woodland (Jacobsen 1974), *Capparis tomentosa* thickets (Waser 1975) and *Capparis tomentosa* and *Securinega virosa* shrubland (Okiria 1980). The bushbuck in the Zambezi valley were found to frequent dry thickets along temporary water courses (Wilson & Child 1964; Morris 1973; Jacobsen 1974).

A seasonal difference in habitat utilisation by the bushbuck was reported in Chobe National park by Child (1968) and Simpson (1974). Bushbuck were restricted to the riparian forest fringe during the dry season months. As the vegetation came into leaf with the onset of the rains some bushbuck moved away from the river (Child 1968; Simpson 1974).

Suitable habitat conditions may include cover for predator evasion (Waser 1975; Allen-Rowlandson 1986) or suitable plant species for food (Mentis 1973). It is difficult to isolate these two criteria since some habitats provide both cover and food concurrently. Bushbuck are not physically adapted to out-run their predators, hence lateral cover could be important for concealment purposes. In Weza forest plantation in South Africa, Allen-Rowlandson (1986) found that areas where lateral cover was high but canopy cover low were not favoured by bushbuck during the day.

Thompson (1972) reports that bushbuck favoured *Baikiaea plurijuga* woodland with high canopy cover in Victoria Falls National park, Zimbabwe. Simpson (1974) stated that bushbuck habitat requirements were focused on the lower vegetation strata rather than canopy cover. He stressed the importance of lateral cover in determining the points of access to and from the river by the bushbuck (Simpson 1974). Morris (1973) reported that bushbuck in his study area favoured river and drainage lines with ample cover.

Bushbuck have been reported to move into more open habitats at night time (Waser 1975; Okiria 1980; Allen-Rowlandson 1986). Waser (1975) suggested that this utilisation of different habitats during the day and night was an anti-predatory strategy. For bushbuck one significant difference between night and day time is the relative usefulness of vision to their predators.

Allen-Rowlandson (1986) was critical of Simpson's (1974) statement that "the limiting factor governing the seasonal dispersal and concentration was the availability of surface water" and emphasised that bushbuck "were never seen to drink at Weza, nor did water appear important in Waser's (1975) study along the Mweya peninsula, Uganda". He concluded that "an equally probable explanation of why bushbuck are associated with water courses and drainage lines may be due to the vegetation such areas provide as both food resources and cover for concealment during the day".

1.3.2.5 Bushbuck activity

Waser (1975) reports that bushbuck exhibited a cyclic pattern of activity throughout the 24 hours. They showed periods of 2 to 3 hours resting followed by a similar duration of activity with noticeable crepuscular movements. Reports of a mid day feeding spell could imply that the bushbuck foraging behaviour is predator influenced, since they are utilising periods when potential predators may be inactive. Predators are found to be lying up over the hottest part of the day when they are unable to actively hunt due to their thermal limitations (Waser 1975).

In Weza National Park, Uganda resting, lying and ruminating were the most frequent activities of bushbuck from 0700 to 1300 hours. There were periods in between when bushbuck stood up to stretch their legs. Light feeding occurred between 1300 and 1800 hours followed by resting from 1800 to 2100 hours. Feeding and resting were more frequent at night (Okiria 1989). In contrast bushbuck were observed feeding and walking more during the day than at night in Kafue National Park, Zambia (Simbotwe & Sichone 1989).

1.4 Study area

1.4.1 Location and size

In the northern region of Botswana lies Chobe National Park, a natural wilderness area covering 11,700 km^2 with habitats ranging from swamp and floodplain to old lake beds, sand ridges and forests (Fig 1.1). The Park is situated between latitudes 17°48'S - 19°00'S and longitudes 23°50'E - 25°10'E. It is unfenced and its boundaries are delimited by natural features or surveyed cutlines, which pose no restriction to animal movements. In 1984 in the south-west corner of the park a corridor was established which linked the park with Moremi Game reserve. The Kachikabwe Enclave, an area with human settlement, is a designated forest reserve situated between the Chobe and Linyanti rivers and the park boundary.

The Kwando river originates in the highlands of Angola. From there it meanders southwards through the Caprivi strip. As the river reaches the border of the Chobe National Park it changes course and flows north eastwards where it becomes the Linyanti river. After flowing through Lake Liambizi the Linyanti becomes the Chobe river. From here the Chobe meanders eastwards until it reaches the Zambezi river (Fig 1.1).

The park boundaries consist of a northern boundary which follows the Chobe and Linyanti rivers, along the international border between Botswana and Namibia (Caprivi Strip). In the east the park borders the neighbouring Kasane forest reserve (plus its extension south) and the Maikaelelo forest reserve. The western boundary is delimited by a cutline along the 23°50'E longitude and the southern boundary by a cutline along the 19°00'S latitude.

1.4.2 Climate

The climate of Kasane (in the north-east corner of the Park) is typified by cool dry winters and warm wet summer seasons. The coolest months are June through July with mean minimum temperatures of 11°C in July, whilst the hottest months are September through November with a mean maximum temperature of 36°C recorded in October (Table 1.1). During the winter months the fairly warm daylight hours are a sharp contrast to the night time temperatures (Child 1968; Sommerlatte 1976).

Annual rainfall (recorded at Chobe Game Lodge since 1984) averages 552 mm (range from 312 to 858 mm) (Table 1.2). The length of the dry season (months when no rainfall is recorded) is ecologically significant and can vary from 2 to 8 months with an annual mean of 4.3 rainless months. 1991 was a year when no rain fell for 6 months. Localised thunderstorms are common during these warm months influenced by the temperature of the Mozambique channel (Anderson 1970) causing the unstable atmospheric conditions experienced during the summer.

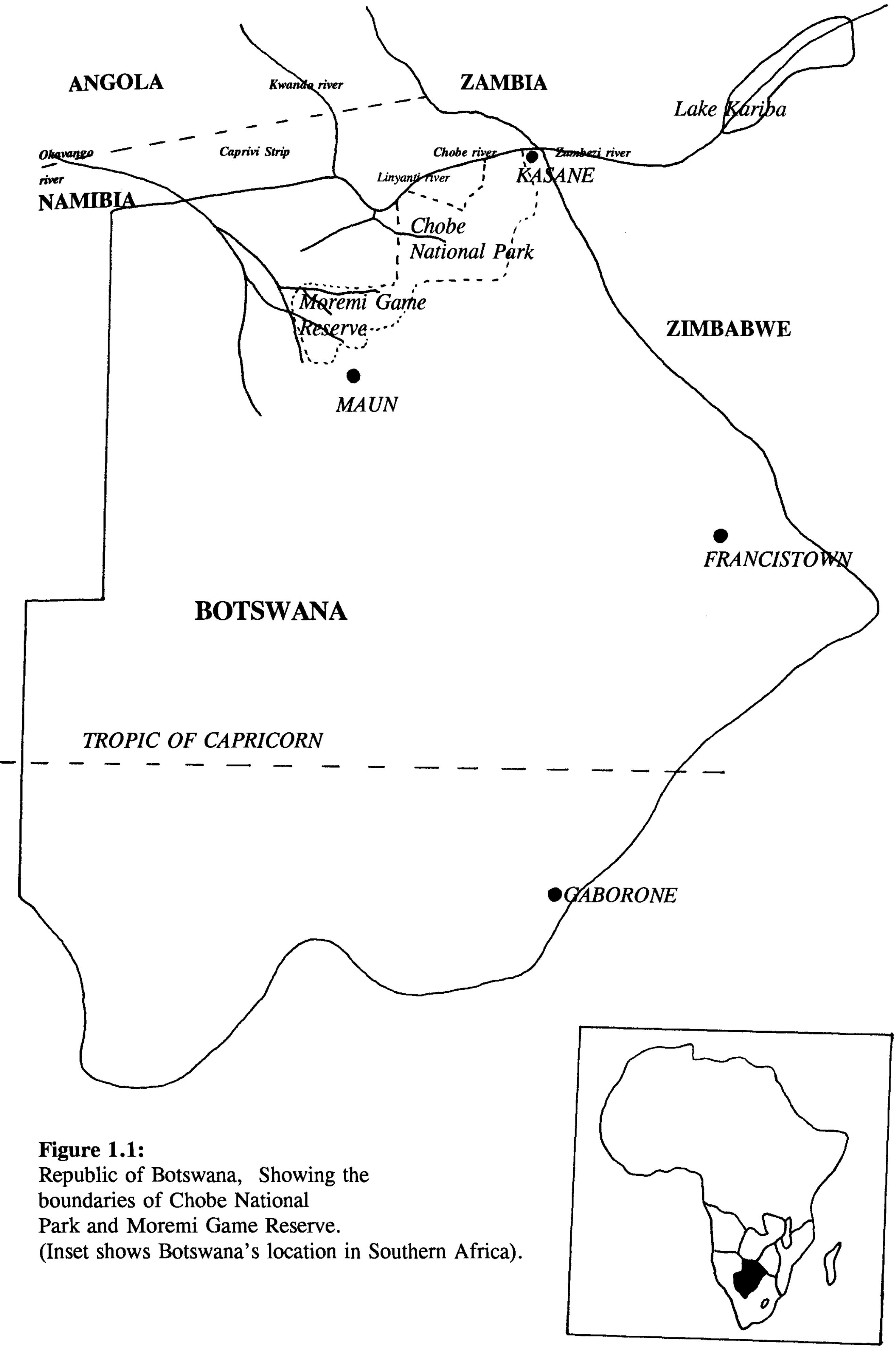

Figure 1.1:
Republic of Botswana, Showing the boundaries of Chobe National Park and Moremi Game Reserve.
(Inset shows Botswana's location in Southern Africa).

Table 1.1: Temperature and rainfall records for Kasane for 1991-1992

MONTH	MEAN MINIMUM TEMPERATURE (°C)	MEAN MAXIMUM TEMPERATURE (°C)	RAINFALL (mm)
MAY 1991	13.5	29.2	0.00
JUNE 1991	11.5	26.9	0.00
JULY 1991	10.9	26.5	0.00
AUGUST 1991	13.2	30.5	0.00
SEPTEMBER 1991	19.2	34.9	0.00
OCTOBER 1991	20.0	35.0	11.0
NOVEMBER 1991	20.1	32.9	33.5
DECEMBER 1991	14.4	29.3	286.0
JANUARY 1992	19.9	31.8	74.5
FEBRUARY 1992	20.4	35.8	0.00
MARCH 1992	20.1	32.4	33.0
APRIL 1992	17.7	32.1	12.0

Table 1.2: Rainfall recorded at Chobe Game Lodge from 1984. (annual totals from May to April)

YEAR	RAINFALL (mm)
1984 - 1985	666
1985 -1986	555
1986 - 1987	312
1987 - 1988	858
1988 - 1989	496
1989 - 1990	592
1990 - 1991	483
1991 - 1992	450

From January to April the rains are more widespread. This is a direct influence of the damp more stable air coming from the warmer Indian ocean coastal waters (27°C) and moving over the interior. The Southern boundary of the Intertropical Convergence Zone (ITCZ) which usually lies just north of Botswana (Anderson 1970) occasionally moves south bringing heavy rains to northern Botswana.

Over the 8 years the average rainfall at Chobe Game Lodge has been within the range 312 to 858 mm. The 1991/1992 rainy season began with the first rains falling on October 17th 1991. Monthly rain peaked in December and the last rains of the season fell in March 1992 (Table 2.1). The total rainfall (between May 1991 and April 1992) recorded at Chobe Game Lodge measured 450 mm. This was below average for the area and was the lowest annual rainfall recorded since 1986/87. Sixty-three percent of the annual rain fell during December, whilst 51% of the total rain fell over a 10 day spell from 20th to 29th December. Rainfall records from the previous wet season also indicated below average rainfall. For the 1990-1991 wet season 80% of the annual rain fell after December.

1.4.3 Topography and soils

The general environmental characteristics of the Chobe National Park and the adjacent areas were dealt with in earlier reports by Blair-Rains and Mckay (1968) and Child (1968). The soils of the Chobe district were summarised by Siderius (1972) and Sommerlatte (1976). The soils are mostly derived from sandy material. Other soils are derived from lacustrine and riverine deposits, whereas some are basalt and lithomorphic in origin (Sommerlatte 1976). Kalahari sands form the sand ridge and the upper part of the slope (Simpson 1974). These characteristically red/brown soils are infertile, structureless, porous and free draining (Blair-Rains and Mckay 1968) and low in organic content (Simpson 1974).

The general topography of the study area between Park headquarters and Ihaha consists of a uniform slope which drops from the sand ridge at approximately 948 m down to the Chobe river at 854 m. The length of this slope varies from less than 0.5 km near Kasane to over 2.7 km west of Serondella (Simpson 1974). There are three main dry drainage lines which lead northwards into the Chobe river. These are (starting from the eastern limit of the park):

(i) Sidudu valley situated just after park headquarters,
(ii) Kalwizi valley, just west of Chobe Game Lodge; and
(iii) the drainage line opposite Kabulabula (in the western section of the general study area) which becomes lost on the flats before reaching the river (Simpson 1974).

The former two valleys are easily recognisable and extend for some distance south of the sand ridge. Along the high flood line of the river a second smaller sand ridge is distinguishable. The annual floods from March through to May have been known to reach up to this high flood line. The smaller sand ridge running roughly along the high flood line is shaped by underlying calcrete and forms a powdery clay on the riverine plain. Below this calcrete ridge is found the heavy alluvial clay soil which is known locally as "Cotton Soil" (Simpson 1974).

CHAPTER 2

2.0 THE DECLINE IN THE BUSHBUCK POPULATION ALONG THE CHOBE RIVER FRONT

2.1 INTRODUCTION

Twenty one years ago Simpson (1974) undertook a comprehensive study on the ecology of the Zambezi valley bushbuck along the Chobe river. His conclusion was that "the bushbuck numbers appear to have stabilised over the past 5 years (1965 to 1970), but they cannot maintain themselves in the face of progressive habitat deterioration through over-utilisation". This habitat "denudation" he attributed to the increased elephant numbers along the Chobe river during the dry season. Both Child (1968) and Simpson (1974) pointed out that bushbuck may decline with increased elephant concentrations in the dry season.

Concern has been expressed that the bushbuck numbers have declined along the Chobe river front (Gibson 1990). Various reports have expressed concern as to the effect of increased numbers of elephants which utilise the Chobe river front in the dry season months (Child 1968; Simpson 1974; Sommerlatte 1976; Moroka 1985; Melton 1985). It is this heavy utilisation of the vegetation over a few months of the year that has caused concern as to the status of animals associated with the riparian vegetation types. The question arises as to whether or not the Chobe bushbuck (*Tragelaphus scriptus ornatus)* can persist despite these changing conditions.

The aim of the investigation reported in this chapter is to compare my bushbuck population estimate results with those documented by Simpson (1974) to determine the extent of the population change since 1969/1970, and to assess whether the decline was severe along the whole river front. In order to do this it was necessary to use the same study area and similar censusing methods as that used by Simpson (1974) for comparative purposes.

The specific objectives were:

(i) to estimate the current abundance of bushbuck along the Chobe river front in 3 sectors: the general study area, an intensive study area and the river frontage;

(ii) to compare the 1969-1970 and 1991 population estimates to determine the extent of the population change.

(iii) to assess the current demographic status of the bushbuck population as indicated by the proportion of juveniles and the adult male to female ratio.

2.2 STUDY AREA

2.2.1 General study area

The general study area (GSA) included the region from the Chobe park headquarters in the east near Kasane to Ihaha in the western reaches of the park (Fig 2.1). This covered a distance along the roads of 54 km and did not extend much further than 1 km from the river. Roads followed the same route as delimited by Simpson (1974) except for a section in the intensive study area where some of the roads were no longer present.

2.2.2 Intensive study area

The intensive study area (ISA) was situated at the eastern end of the general study area (GSA). The standardised routes covered 7.1 km along the established tourist roads (Fig 2.2). My ISA covered the same 2.8 km stretch of river frontage between "Crocodile island" and "Rhino Pens" as Simpson's (1974) ISA. The exact route which Simpson followed could not be replicated in my study since some of the roads no longer existed. Figure 2.2 shows the difference in the routes used for each study. Simpson's route as determined from aerial photographs, followed 6.4 km of tourist track and enclosed a smaller area (1.0 km^2) than my ISA (1.7 km^2).

The Kasane-Serondella road formed the southern limit of my study area. In the section between the western end of Chobe Game Lodge and Bushbuck Drive, my route went closer to the river than Simpson's and between Bushbuck Drive and Rhino Pens it extended further south than his. His route ran in an approximately parallel line to the river in this section of the intensive study area (Fig 2.2).

2.2.3 River area

The route used for the river censuses was situated between "Crocodile Island" in the west and "White-Sands" near "Rhino Pens" in the eastern end. This river route encompassed a 2.8 km stretch of river frontage of the ISA and was exactly the same as that followed by Simpson (1974) 21 years ago. This made it possible to compare the mean number of bushbuck seen per count along the river in a favourable vegetation type.

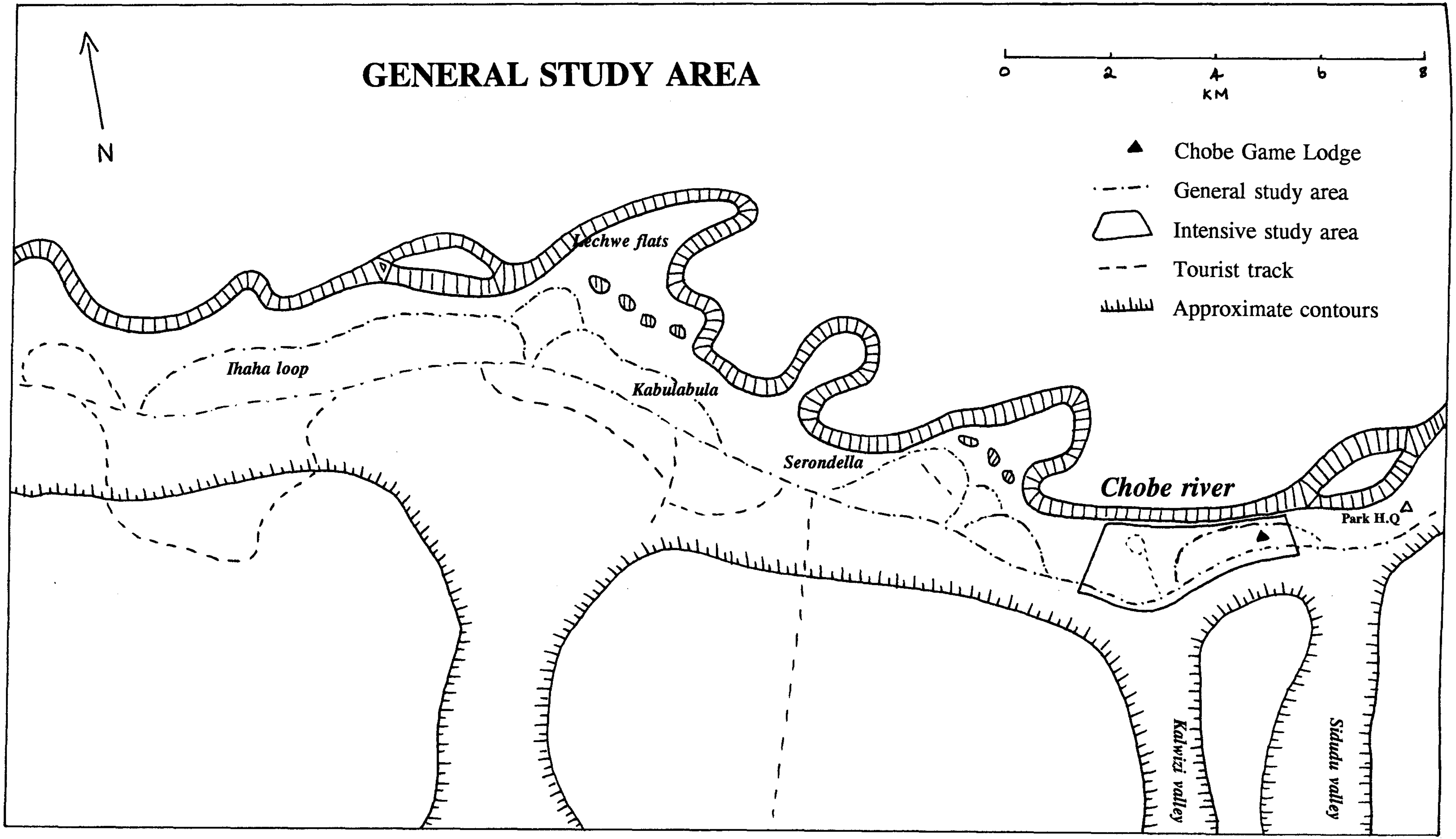

Figure 2.1: General study area showing 1969/70 and 1991 census routes

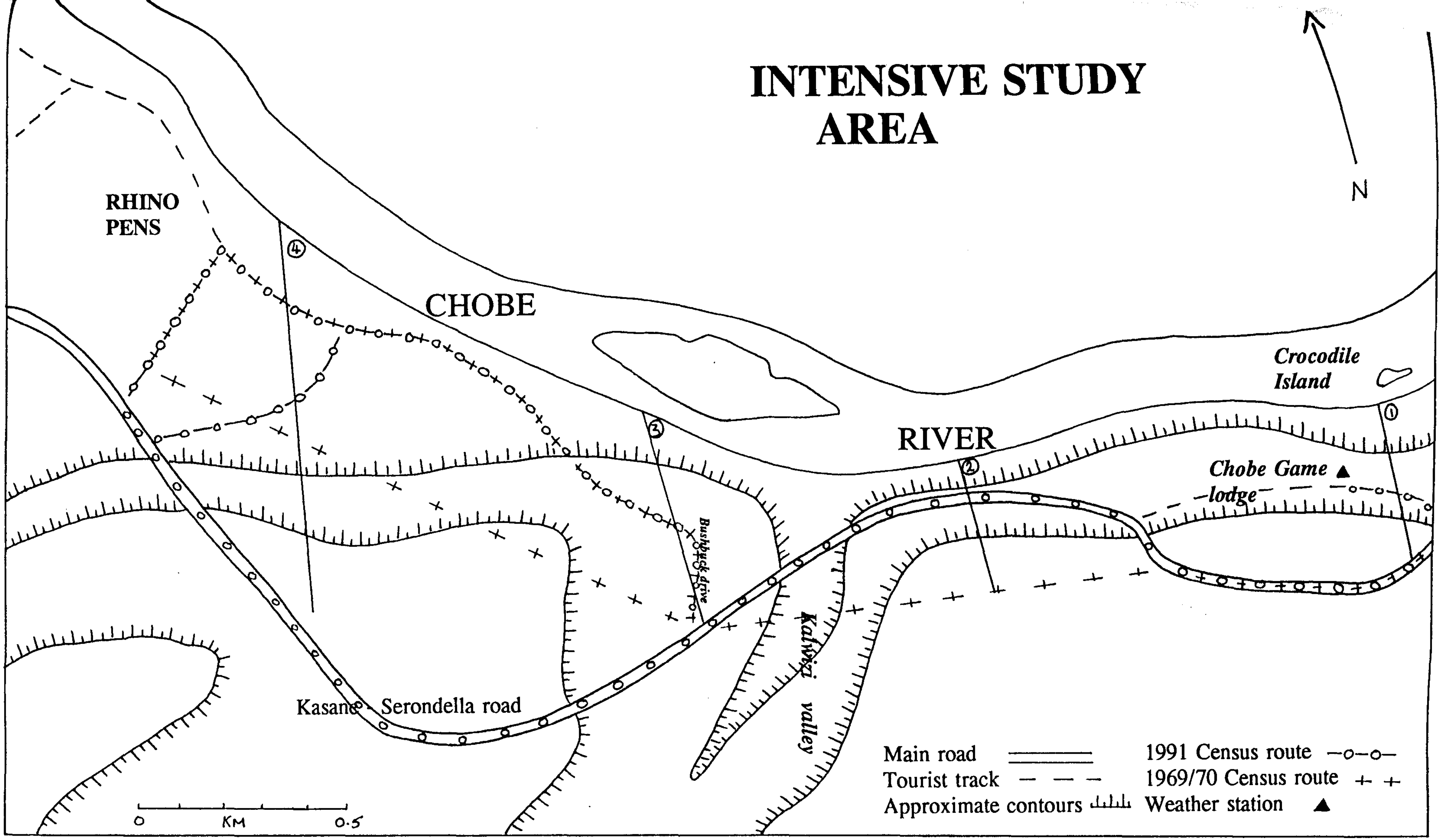

Figure 2.2: Intensive study area showing 1969/1970 and 1991 census routes

2.3 METHODS

Several census methods have been employed in the enumeration of species similar to bushbuck in a variety of habitats and areas. These include the mean sighting distance, where the distance of all the animals observed is measured at 90° to the transect or road (Robinette et al 1974; Burnham et al 1980; Milligan et al 1982), road strip counts (Foster & Coe 1965; Dasmann & Mossman 1962), strip counts by foot (Dasmann & Mossman 1962), dung pellet counts (Von Gadow 1978), drive counts (Odendaal et al 1980), track counts (Odendaal et al 1980) and identification of known individuals in a delimited area (Jacobsen 1974; Waser 1975; Allsopp 1978).

The choice of census method for this study was influenced by the relatively low numbers of bushbuck, their size and behaviour and the vegetation types at Chobe, as well as the financial limitations. Additionally it was important to use a census method comparable to that used by Simpson (1974).

Road counts are open to criticism and bias since the road system is unlikely to be representative of the area. Usually roads cover optimum game viewing areas and run along rivers. Road counts are generally used in areas where access off road is difficult or impossible (Norton Griffiths 1975). The advantage in using road counts is that the observer can stop the vehicle and make incidental observations on behaviour, age, sex and vegetation type. Both standard and modified strip sampling techniques have been used. The standard strip sampling method uses a fixed strip width chosen before the census. Only those animals seen within this pre-selected strip are recorded (Eberhardt 1976). The modified strip transect method involves estimating (rather than pre selecting and fixing) the strip width from field measurements taken from the transect line (road) before, after or during the strip sampling. Various methods of securing an unbiased estimate of the effective strip width have been used in wildlife censuses (Collinson 1985). These are discussed in Appendix A.

Enumeration of the animal population using the known individual method requires that the observer distinguishes individual animals in a delimited area. This method is more time consuming in the initial stages of the study until a photo and sketch album of all the individuals has been constructed. The main purpose of the river counts was to determine the density of the bushbuck along the riparian fringe woodland. Additionally bushbuck could be approached at fairly close quarters from the boat and hence I could record their natural markings, which appeared to be unique to each bushbuck.

2.3.1 Bushbuck abundance

Bushbuck numbers and distribution were determined by road and river counts from the 17th July 1991 to the 30th November 1991. Road counts were conducted in the early mornings between 06:00 hours and 09:00 and in the evenings between 16:30 and 19:30. The effect of any bias was reduced by running the routes from alternate directions each time. The GSA counts were started from the park headquarters either following the river route first or the main Serondella road first. The ISA counts were begun either in the eastern end of the ISA at the Game Lodge opposite "Crocodile Island," or from the "Rhino Pens " in the western end of the ISA.

An average speed of 20 km h^{-1} was maintained and stops were made to identify and classify the animals seen en-route. Each GSA census lasted on average 3 hours. The ISA censuses lasted on average 2 hours since more detailed (time consuming) information was required in the ISA. At the start of each road count the odometer reading was taken and subsequently recorded at each bushbuck sighting. Whenever a bushbuck was sighted the following were recorded:

(i) date and time;
(ii) location at which the bushbuck was first sighted;
(iii) sex and age - adult or juvenile;
(iv) vegetation type first seen in;
(v) activity;
(vi) identification of individual.

For the river counts the boat was kept at a constant speed and distance from the river bank. Travelling was from opposite directions on successive trips. River censuses were run in the early mornings between 06:00 and 09:00 hours and in the evenings between 16:30 to 19:30 hours. The same data listed above were recorded whenever a bushbuck was sighted from the boat. The length of the area sampled was determined from aerial photographs. The riparian fringe in the ISA was situated on a slope which was steeper in the area east of Kalwizi. The section of the riparian fringe which was included during the road counts could be observed from the road and also from a point at the western end of the ISA which enabled the whole of the riparian fringe to be observed from the river to the top of the slope.

2.3.2 Identification of known individuals

A photo and sketch scheme to identify the individuals within the intensive study area was used. Natural spot and stripe patterns were good identifying features, especially those around the face and on the hindquarters. These patterns appear to be distinct for each animal. Ear nicks and broken horns also proved good identification marks (See fig 2.3). The photo and sketch method involved making a quick sketch of bushbuck sighted during the road and river censuses as well as while the vegetation data was collected. Photographs of both sides of the body were taken whenever possible to build up an identity record. Later the photographs were used along with the sketches to form a complete picture of individual spot and stripe patterns. These were then used for quick reference in identifying bushbuck on subsequent censuses. A sketch album of the known individual bushbuck was built up. From the known individuals a density estimate of bushbuck in the ISA was determined. The total area of the ISA was estimated by overlaying a grid on an aerial photograph. The home range of some of the bushbuck seen within the ISA probably extended further out of this delimited area. To account for this edge effect, half the diametre of the average home range was added to the east and west boundary's to estimate the effective ISA sampled. The river bounded the north and the south was bounded by an inland region which had no resident bushbuck. From the maximum distance between sightings of the individuals in the ISA, I estimated the average diameter of the home range for the known individuals.

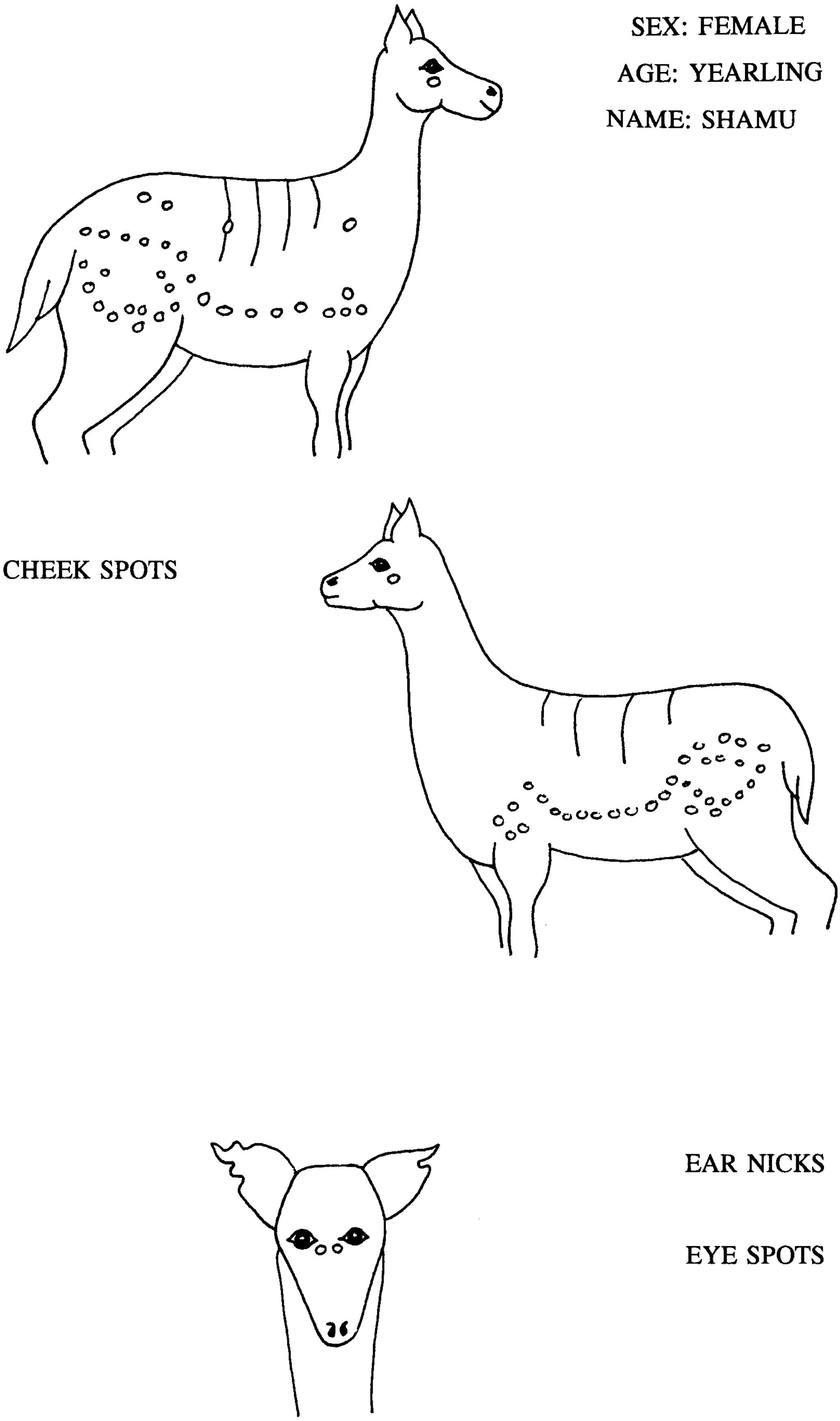

Figure 2.3: Sketch system used for identification of bushbuck

2.3.3 Methods used for comparison with Simpsons 1969-1970 results

Only the monthly mean number of bushbuck per count and the derived densities were available from Simpson's (1974) results. There were no results for July 1969. I combined the four monthly mean number of bushbuck per count from 1969 with the five from 1970 to obtain an overall mean number of bushbuck per count. The variance was calculated from these 9 estimates. This procedure was also performed for the GSA, ISA and the river counts. Simpson (1974) estimated the monthly effective strip width by measuring the distance at which a board was no longer visible. He calculated the effective area sampled each month for each vegetation type. The mean monthly effective areas sampled for 1969/1970 and 1991 are expressed in Table 2.1. I combined his monthly estimates of the areas sampled for the four months in 1969 with those for the five months in 1970 to get an overall mean sample area. The variance was calculated from these 9 estimates. For comparative purposes, to calculate the density of bushbuck in the ISA for 1991, I used the overall mean monthly number of bushbuck recorded per count and the mean effective strip widths as shown in Table 2.1.

Table 2.1: The mean monthly effective areas sampled for 1969/1970 and 1991

MONTH	AREA SAMPLED (m^2)		
	1969	1970	1991
JULY	NO RECORD	0.16	0.34
AUGUST	0.17	0.16	0.34
SEPTEMBER	0.21	0.20	0.34
OCTOBER	0.25	0.24	0.34
NOVEMBER	0.17	0.20	0.26
OVERALL MEAN	0.20		0.32
STANDARD DEVIATION	0.03		0.04
VARIANCE	0.001		0.001

In Simpson's (1974) report there is an error in the anual mean density estimated from the river counts. A quotation from his thesis (pages 118-119) reads:

".....the area evaluated would be 13.1 acres (0.053 km^2). The annual mean number of bushbuck per count was 7.6 animals, giving a density along the riparian forest fringe of 1 bushbuck per 1.7 acres (145 per km^2)." In a table on the following page there is an error in the annual mean density which is reported as being " 5.7 acres per bushbuck", or 43 bushbuck per km^2. This has been cited by Odendaal & Bigalke (1980) and Allen-Rowlandson (1986). It should read "1.7 acres per bushbuck", or 145 bushbuck per km^2.

2.3.4 Population structure

The demographic status of the bushbuck population was indicated by the proportion of juveniles in the population as well as the adult male to female sex ratio. Every bushbuck sighted was assigned to one of three classes; sub-adult plus adult male, sub-adult plus adult female or juvenile. In some cases this was not possible since the animal was only sighted briefly because it moved away or because of the density of the vegetation or both. Such sightings were assigned to the unclassified class.

Adult males are clearly distinguishable from females since they possess horns. Once the horn buttons appeared at about 6 months, males were classified as sub-adults. The appearance of horn buttons at 6 months was based on personal observations of a male bushbuck (J1), probably born in the ISA on August 14th 1991. When he was first seen on that day he was very wobbly and unstable on his feet. I had the opportunity to observe him repeatedly and noted that by mid February his horn buttons were visible. Juveniles were defined as those seen with their mothers and seen to suckle.

2.4 DATA ANALYSIS

2.4.1 Bushbuck abundance in 1991

2.4.1.1 *Count indices*

A count index (CI), the mean number of bushbuck seen per count per unit distance travelled was determined for the GSA and the ISA . This enabled comparison of bushbuck numbers seen in the two areas. A two tailed t-test was used to determine if the significance of the differences.

2.4.1.2 *Density and population estimate of bushbuck in the intensive study area*

The number of bushbuck in each vegetation type, corrected by the visibility profile correction factor and the effective strip widths were used to calculate the overall density of bushbuck in the ISA (see Appendix A). A count index representing the number of bushbuck seen per distance travelled along the river was calculated from the information collected during the river censuses.

2.4.2 Comparison with 1969-1970 results

The two-tailed t test was used to determine if there was any difference in the overall mean number of bushbuck seen per count and the densities in the ISA over the 21 years. The following formula was used (Sokal & Rohlf 1973):

$$t = \frac{\text{Difference between two means (d)}}{\text{Standard error between the two means (Ed)}}$$

where:

$$(Ed)^2 = \{(a + b) \div c\} \times \{d \div e\}$$

$a = (n_1-1) \times (s_1^2)$

$b = (n_2-1) \times (s_2^2)$

$c = (n_1+n_2-2)$

$d = (n_1+n_2)$

$e = n_1 \times n_2$

where n_1 = number in sample 1

n_2 = number in sample 2

s_1^2 = variance of sample 1

s_2^2 = variance of sample 2

2.5 RESULTS

2.5.1 Bushbuck abundance in 1991

A total of 86 road counts was undertaken in the GSA from July to November. Two hundred and forty nine bushbuck were sighted which gave a mean of 2.9 (sd = 1.84) bushbuck per count (Table 2.2). There was no significant difference between the monthly mean counts. A maximum of 9 bushbuck was recorded in one count in August.

In the ISA a total of 97 road censuses yielded 257 bushbuck with a mean of 2.7 (sd = 1.8) bushbuck per count (Table 2.3). The corrected mean using the visibility profile correction factor was 3.1. There was no significant difference in the number of bushbuck seen among months.

Table 2.2: Mean number of bushbuck per count with their confidence limits recorded during the general area censuses from July to November 1991

MONTH	MEAN NUMBER PER COUNT	NUMBER OF COUNTS	STAND. ERROR	95% CONFIDENCE LIMITS	MAXIMUM NUMBER PER COUNT
JULY	3.27	15	0.43	2.35 - 4.19	6
AUGUST	3.09	23	0.47	2.12 - 4.06	9
SEPTEMBER	2.58	19	0.33	1.90 - 3.26	5
OCTOBER	2.23	15	0.30	1.57 - 2.83	5
NOVEMBER	3.64	14	0.56	2.44 - 4.84	7
TOTAL	2.93	86	0.20	2.54 - 3.32	

Table 2.3: Mean number of bushbuck seen per count recorded during the intensive study area road censuses from July to November 1991

MONTH	MEAN NUMBER PER COUNT	CORRECTED NUMBER PER COUNT	NUMBER OF COUNTS	STANDARD ERROR	95% CONFIDENCE LIMITS	MAXIMUM NUMBER PER COUNT
JULY	2.73	3.0	11	0.45	1.73-3.73	5
AUGUST	2.50	2.69	26	0.28	1.93-3.07	5
SEPTEMBER	2.83	3.0	18	0.33	2.13-3.53	6
OCTOBER	2.57	2.71	21	0.42	1.69-3.45	8
NOVEMBER	2.76	4.14	21	0.57	1.57-3.95	8
TOTAL	2.65	3.10	97	0.19	2.46-2.84	

A total of 214 sightings of bushbuck was recorded during the 33 river censuses that took place during the study period. The mean number of bushbuck per count was 6.3 (sd = 2.9) (Table 2.4). There was a significant drop in the number seen per count from a mean of 7.5 in October to a mean of 4.1 in November ($t_{40, 2\alpha} = 5.1$; $p < 0.001$). A maximum number of 12 bushbuck was seen during a river census in August.

2.5.1.1 Count indices

Over the 5 months the mean count index for the GSA was 0.054 ($\pm$ 0.007) bushbuck per km, whereas in the ISA the mean count index was 0.37 ($\pm$ 0.09) bushbuck per km. This value was significantly higher than that for the GSA ($t_{181, 2\alpha} = 4.2$; $p < 0.001$). The ISA route formed 13% of the GSA. Therefore only 0.006 bushbuck per kilometre travelled was recorded in the GSA section outside the ISA.

2.5.1.2 Density and population size

An overall mean density of 9.7 (sd = 7.6) bushbuck per km^2 was calculated from the road counts in the ISA using the visibility profile method. This gave a bushbuck density in the range of 8.1 - 11.3 bushbuck per km^2 for the ISA. By the end of November no new bushbuck were regularly seen in the ISA and a total of 15 individuals had been recognised. The ISA was calculated to be 2.3 km^2 which gave a bushbuck density of 6.5 km^{-2} from the 15 known individuals in the ISA.

The home range diameter for the known individuals is shown in table 2.5. Adult home ranges varied from 13 to 39 ha. Adult male and female home range diametres did not differ significantly ($t_{6, 2\alpha} = 1.76$; $p > 0.05$). This was probably due to the low sample numbers. The average home range diameter for the bushbuck in the ISA was therefore taken as 525 metres (sd =104).

Table 2.4: Mean number of bushbuck per count with their confidence limits recorded during the river censuses from July to November 1991

MONTH	MEAN NUMBER PER COUNT	NUMBER OF COUNTS	STANDARD ERROR	95% CONFIDENCE LIMITS	MAXIMUM NUMBER PER COUNT	NUMBER SEEN WEST OF KALWIZI	NUMBER SEEN EAST OF KALWIZI
JULY	8.25	4	1.25	4.29-12.21	11	14	19
AUGUST	7.00	4	2.28	-0.23-14.23	13	9	19
SEPTEMBER	7.33	6	0.42	6.25-8.41	9	5	39
OCTOBER	7.50	7	0.67	5.86-9.14	9	5	55
NOVEMBER	4.08	12	0.70	2.54-5.62	9	9	40
TOTAL	6.29	33	0.51	5.29-7.29		42	172

Table 2.5: Home range diametres estimated for known individual bushbuck in the intensive study area

KNOWN INDIVIDUAL	SEX	HOME RANGE DIAMETRE (m)	NUMBER OF SIGHTINGS	HOME RANGE (ha)
F1	FEMALE	500	25	20
F2	FEMALE	500	16	20
F3	FEMALE	600	18	28
F4	FEMALE	400	20	13
F5	FEMALE	400	35	13
M1	MALE	500	21	20
M2	MALE	700	26	39
M3	MALE	600	15	28

KEY: F = FEMALE; M = MALE

2.5.2 Comparison with 1969-1970

2.5.2.1 *General study area*

During the GSA road counts the maximum number of bushbuck seen on a single count during 1991 was 9 individuals in August. Simpson (1974) reported a maximum of 39 bushbuck on a single count in July 1970.

The mean numbers of bushbuck per count in the GSA for both studies are shown in Table 2.6. From Simpsons combined monthly results the overall mean was 19.3 (sd = 6.8) bushbuck per count for 1969-1970. The overall mean per count for the 1991 GSA was 2.9 (sd = 1.8). This difference was highly significant ($t_{93,2\alpha} = 18.1$; $p < 0.001$). Bushbuck numbers in the GSA appear to have declined to about 15% (95% confidence range of 6% - 24%) of the 1969/1970 level.

Table 2.6: The mean number of bushbuck per count recorded in the general study area from Simpsons 1969 & 1970 results and from my 1991 study

MONTH	YEAR		
	1969	1970	1991
JULY	NO RECORD	20	3.3
AUGUST	22	17	3.1
SEPTEMBER	31	14	2.6
OCTOBER	29	15	2.2
NOVEMBER	12	14	3.6
OVERALL MEAN	19.3		2.9
STANDARD DEVIATION	6.8		1.8
NUMBER OF SAMPLES	9		86

2.5.2.2 *Intensive study area*

Table 2.7 shows Simpson's monthly mean number of bushbück per count in the ISA and the corresponding areas sampled. The overall bushbuck density using the mean number per count and the effective strip width for 1969/1970 was 25 (sd = 10.5) per km^2 compared to 8.4 (sd = 5.7) per km^2 in 1991. The overall density from the 1970 results was significantly higher than the 1991 densities ($t_{104, 2\alpha}$ = 13.8 p <0.001). Table 2.8 shows that there has been a drop in the number of bushbuck over the 21 years. The drop in bushbuck densities in the ISA has been to about 34% (95% confidence range of 24 - 43%) of the 1969/1970 level (Table 2.8).

From the 1969-1970 results the count index for the GSA was 0.36 and for the ISA was 0.78 but the difference was not significant ($t_{16, 2\alpha}$ = 1.1; p > 0.05). In 1969/1970 the ISA route took up 12% of the GSA thus the area outside the ISA had 0.27 bushbuck per kilometre travelled. There had been a drastic decline in the section of the GSA which excluded the ISA, to 2% of the former level.

The mean numbers of bushbuck seen per count during the river censuses are shown in Table 2.9. There is a significant decline in the number seen per count, from a mean of 10.2 (± 1.6) in 1969-1970 to a mean of 6.3 (± 0.9) in 1991 ($t_{40,2\alpha}$ = 4.24; p < 0.001)(Table 2.8). Numbers in the riparian fringe had declined to 62% (between 43% and 80%) of their former level.

Table 2.7: Monthly mean number of bushbuck seen per count and area sampled for the intensive study area, taken from Simpsons 1969 & 1970 data

MONTH	MEAN NUMBER OF BUSHBUCK PER COUNT		AREA SAMPLED (Km^2)	
	1969	1970	1969	1970
JULY	NO RECORD	7.1	NO RECORD	0.16
AUGUST	3.7	7.9	0.17	0.16
SEPTEMBER	5.8	7.5	0.21	0.20
OCTOBER	2.7	3.5	0.25	0.24
NOVEMBER	3.1	3.3	0.17	0.20

Table 2.8: Overall mean number of bushbuck seen per count recorded in the intensive study area for both studies

	1969/1970	1991
MEAN	5.0	2.7
STANDARD DEVIATION	2.1	1.8
VARIANCE	3.9	3.3
NUMBER OF SAMPLES	9	97
95% CONFIDENCE LIMITS	3.4 - 6.6	2.3 - 3.1

Table 2.9: The mean number of bushbuck per count recorded during the river censuses for Simpsons 1969 & 1970 results and for my 1991 study

MONTH	RIVER CENSUS		
	1969	1970	1991
JULY	NO RECORD	11.6	8.3
AUGUST	12.5	16.1	7.0
SEPTEMBER	9.6	14.2	7.3
OCTOBER	7.8	12.2	7.5
NOVEMBER	1.8	6.2	4.1
OVERALL MEAN	10.2		6.3
STANDARD DEVIATION	4.4		2.8
VARIANCE	17.2		3.1
NUMBER OF COUNTS	9		33

2.5.3 Population structure

Out of the 257 bushbuck observations during the ISA road counts, adult and sub-adult females accounted for 51% of the total sightings. The adult and sub-adult sex ratio was 23 males to 100 females (Table 2.10). The adult and sub-adult sex ratio from the river counts was 44 males to 100 females (Table 2.11). Of the known individuals there were 3 adult males and 5 adult females. There were 4 known juveniles to 5 adult females in the ISA. The number of juveniles observed during the ISA road counts increased towards the end of the dry season (October and November). Two juveniles were first seen in October and they were very unstable on their feet so I estimated that they were only a couple of days old. There was a significant difference in the number of juveniles seen in October and November (65:100) compared to the other three months (10:100) ($\chi^2 = 13.7$, df = 2; $p < 0.001$).

Table 2.10: Age classes of bushbuck seen in intensive study area, expressed as the number of bushbuck seen

MONTH	ADULT MALE	ADULT FEMALE	UNCLASSIFIED	JUVENILE	TOTAL
	N	N	N	N	N
JULY	8	15	6	1	30
AUGUST	5	32	23	5	65
SEPTEMBER	7	33	8	3	51
OCTOBER	2	30	6	15	53
NOVEMBER	8	21	11	18	58
TOTAL	30	131	54	42.0	257

Table 2.11: Age classes of bushbuck seen along the river, expressed as a number of bushbuck seen

MONTH	ADULT MALE	ADULT FEMALE	UNCLASSIFIED	JUVENILE	TOTAL
	N	N	N	N	N
JULY	5	19	6	3	33
AUGUST	10	13	3	2	28
SEPTEMBER	14	19	6	5	44
OCTOBER	12	36	7	5	60
NOVEMBER	10	30	7	2	49
TOTAL	51	117	29	17	214

2.6 DISCUSSION

Bushbuck abundance in 1991

For the duration of my study (July 1991 to November 1991) there were no significant changes in the mean monthly number of bushbuck seen during road counts. Little rain had fallen by November although there was a flush of growth in the vegetation and a reduction in the lateral visibility. Child (1968) found that bushbuck numbers seen in the GSA peaked in November 1965 and again in October 1966. Simpson (1974) reported a peak in numbers in September 1969 and in July 1970, but no significance can be attached to the recorded variability.

The 15 known individuals represented the population estimate for the number of bushbuck in the ISA. The home range of the known adult bushbuck varied from 13 to 39 hectares. Along the Mweya peninsula, Uganda, the home ranges varied from 6.3 ha for females to 35.2 ha for males (Waser 1975). In Nairobi National Park, Kenya, bushbuck home ranges varied from 2.5 ha for adult females to 20 ha for sub-adult males. Waser (1975) and Allsopp (1978) report that male bushbuck have larger home ranges than females. In the southern Cape Odendaal & Bigalke (1980) found that the home range varied from 38 ha to 166 ha. During this study however there was no significant difference in the male and female home ranges, which was probably a result of the small sample size. The estimate of the home range size was taken from daytime sightings and therefore probably represented a minimum estimate, since bushbuck may have moved further afield during the night.

Results from the river censuses showed that the bushbuck were seen more frequently in the riparian fringe woodland east of Kalwizi compared to the west. River censuses indicated that there was some movement away from the riparian fringe woodland adjoining the river in November. This agrees with previous reports by Child (1968) and Simpson (1974) where bushbuck moved away from the Chobe river once the rains had started and there had been a flush of growth in the adjacent vegetation. In Victoria

Falls National Park, Zimbabwe, Thompson (1970) found a correlation between the distance of the bushbuck from the river and the rainfall. Bushbuck were reported to move away from the Sengwa and Lutope rivers, Zimbabwe during the rains (Jacobsen 1974).

The results confirmed that bushbuck numbers had declined along the Chobe river front since 1969/1970. In the intensive study area densities had declined to somewhere between 24% and 43% (about 34%) of the 1969/1970 densities. The decline in bushbuck numbers was more severe outside the ISA. In the section of the GSA which excluded the ISA, numbers had dropped to only 2% of the former levels.

Results from the river counts in the ISA indicated that the extent of the decline in the riparian fringe woodland was not as severe as that estimated from road censuses. The decline over the 21 years had been to about 62% (somewhere between 43% and 80%) of the 1969/1970 level. The higher count indices recorded from the river censuses was due to sampling in a favoured vegetation type. Simpson (1974) reported high bushbuck numbers in the riparian forest fringe. Waser (1975) found high bushbuck densities of 26 km^{-2} in the *Capparis tomentosa* thickets along the Mweya peninsula, Uganda. In the Sengwa and Lutope valleys, Zimbabwe, Jacobsen reports high bushbuck densities of 66 km^{-2} in the *Acacia tortilis* - *Grewia flavescens* woodland.

The extent of the decline was severe in the section of the GSA which excluded the ISA, which suggests that very little suitable habitat for the bushbuck persisted. The areas in the GSA where bushbuck were observed included an area around Hippo Pools, park headquarters, the area around Serondella camp site and the area around Kabulabula and along Ihaha loop where riparian fringe or thickets extended close to the river. Simpson (1974) did not give any detailed locations of bushbuck in the GSA so I could not compare the 1969/1970 and 1991 bushbuck distribution.

It appears from the results that there were areas (pockets) where bushbuck still persisted interspersed by sections which were devoid of bushbuck. Bushbuck still persisted in favourable areas (such as the intensive study area) but at lower levels than 21 years ago.

It would seem that in areas where the decline has been most severe the pockets where bushbuck persisted were spatially isolated. The greater decline in the western section of the GSA could also be attributed to poaching activities in that region combined with vegetation change. Gibson (1990) reports that "game along the western river frontage is scarce and skittish as a result of poaching in that area".

Population structure

The results in the intensive study area indicated a differential adult sex ratio favouring females, as is typical of other bushbuck populations (Child 1968; Thompson 1972; Simpson 1974; Waser 1975; Allen-Rowlandson 1986). Juveniles were seen more frequently in October and November. Newly born lambs were observed in August, October and November, which suggests that although bushbuck gave birth throughout the year there was a peak at the start of the wet season. This agrees with Simpson's (1974) results where he reported "juveniles to be seen more frequently once the rains had started". At this time the lateral cover would be greater, concealing the juveniles from predators. The flush of growth in the vegetation would also ensure that lactating mothers would have a nutritious supply of milk for their young. The breeding success does not appear to have been affected by the preceding drought. The higher proportion of juveniles in October and November suggests that there was a healthy recruitment to the population in the ISA.

CONCLUSIONS

Bushbuck numbers along the Chobe river front were generally lower in 1991 than in 1969/1970. Road censuses and the visibility profile method gave a bushbuck density in the ISA of between 8.1 and 11.3 bushbuck per km^2. There was spatial variation in the extent of the bushbuck decline along the river front. The results confirmed that along the river front between Kasane and Ngoma, there were still pockets where bushbuck persisted, but at lower levels than in 1969/70.

Areas around the Chobe Game Lodge, Serondella camp site and Park headquarters appeared to have higher numbers of bushbuck than other areas along the river frontage. There was an increase in the number of juveniles seen at the start of the rains in the ISA, which indicated that in those areas where bushbuck persisted there was a healthy recruitment to the population.

The river censuses show that bushbuck made less use of the riparian fringe woodland in November than during the previous four months. At this time of the year there was a noticeable flush of growth in the vegetation adjacent to the riparian fringe, which would ensure an abundant supply of food and lateral cover for bushbuck.

CHAPTER 3

3.0 RELATION BETWEEN THE VEGETATION CHANGE AND THE STATUS OF THE BUSHBUCK ALONG THE CHOBE RIVER

3.1 INTRODUCTION

Along the Chobe river the high elephant numbers in the dry season months have resulted in heavy utilisation of the riparian and riverine vegetation (Child 1968; Simpson 1974; Sommerlatte 1976; Moroka 1984; Melton 1985). Child (1968) reported a thin riparian fringe which did not exceed 70 metres and varied from closed canopy to scattered evergreens. The Kalahari sandveld was described as "dense jungle" by Selous (1881; cited in Child 1968) and later by Child (1968), where the visibility was limited to a few metres. Further back from the river the vegetation was more open along the face of the sand ridge (Child 1968).

The opening up of the vegetation along the Chobe river has been attributed to the increasing numbers of elephant (Child 1968; Simpson 1974; Sommerlatte 1976 and Moroka 1985). Canopy cover in the Chobe river front *Acacia* woodland declined at a rate of 4% per year between 1973 and 1983 (Sommerlatte 1976; Moroka 1985). In the riverine woodland the rate of canopy loss was 3.5% per year from 1962 to 1973 and only 0.4% per year from 1973 to 1985 (Parry 1989). Parry (1989) stated that there were some vegetation sites in Chobe National Park where canopy cover in the riverine woodland actually increased from 1973 to 1985. The survey proposed that this was a result of an increase in trees which were not adversely affected by elephant (termed "Elephillic trees" by Parry 1989). If elephillic tree species can increase in the presence of the high elephant densities then sufficient canopy cover may develop to prevent the decline in animal species which require denser canopy cover like the bushbuck (Parry 1989)

The aim of the work reported in this chapter was to assess how the bushbuck population will fare given the vegetation changes that have occurred due to the elephant. The objectives were:

(i) to determine the current composition of the vegetation types;
(ii) to assess the changes in the vegetation since 1969-1970;
(iii) to determine the habitat preference of the bushbuck;
(iv) to examine the site preferences of bushbuck for different activities.

It is important to view the environment from the animal's perspective. What may look like a different habitat (vegetation type) to the researcher (or manager) may be equivalent in terms of features of importance to the study animal. Previous studies on bushbuck have examined vegetation factors in relation to the different habitats (Simpson 1974) but have not looked specifically at the site (within each habitat) occupied by the animal to determine what factors are directly important to it. Within the different vegetation types, bushbuck appear to occupy small sites (or pockets) and leave others unoccupied. I looked at the vegetation factors within these sites and in corresponding adjacent sites (where bushbuck were not observed) to determine which factors made one more attractive than the other.

3.2 METHODS

3.2.1 Current composition of vegetation types

In the Intensive study area (ISA) there were 6 vegetation types, namely riparian fringe woodland, *Croton-Capparis* shrubland, *Combretum-Baphia* shrubland, *Acacia* woodland, *Combretum-Dichrostachys* thicket and a mixed ecotone complex which was confined to the Kalwizi drainage line.

Ten 50 m by 2 m belt transects were sampled in December in each of the vegetation types in the intensive study area. Additionally four belt transects were sampled. They extended from the river edge right through the intensive study area (ISA) on a north-south bearing to the Kasane-Serondella road, which formed the southern limit of the ISA. The position of these four transects is shown in figure 2.2 (Chapter 2). They encompassed the whole spectrum of vegetation types through the ISA from the top of the slope down to the river. Forty-five further transects were sampled in the riparian fringe woodland along the river front between Crocodile Island and Rhino Pens, to determine whether there was any difference in the riparian fringe woodland east and west of Kalwizi valley.

3.2.1.1 *Location of transects in each vegetation type*

The transects in each vegetation types (apart from the riparian fringe transects) were located by walking 50 paces from the road along the north-south (0°) compass bearing to a position P1. From this position four belt transects (50 × 2 m) were delimited at 90° to each other. The next position (P2) was located 50 paces (metres) from P1 (i.e. at the end of one of the transects). At P2, an additional 3 belt transects were located at 90° to each other. The following position P3 was located 50 paces from P2. At this position (P3) 3 belt transects were located at 90° to each other. The riparian fringe woodland consisted of a thin fringe which did not exceed 70 metres so the above method of locating transects was not possible. The 10 belt transects in the riparian fringe vegetation type were therefore located parallel to each other at 50 m intervals. Each followed the north-south compass bearing from the river.

3.2.1.2 *Location of transects along the river frontage*

The 45 belt transects along the river frontage were sampled every 50 m. The first transect was located in the western end of the ISA. The mark for this point was a miss-shaped *Ficus sycamorus* tree. Each subsequent transect was located by walking 50 paces (50 m) along the river edge. Each parallel transect followed the north-south compass bearing. The length of the transects was determined by the width of the riparian fringe. The transect started at the river edge and extended to the top of the slope, from here the next woody species along the transect determined the termination point.

3.2.1.3 *Location of the four belt transects from the rivers edge to the southern limit of the intensive study area*

Each of the four belt transects was positioned in approximately the same area where Simpson (1974) located his four belt transects. Replication was impossible since his transects were not marked permanently. I located the four transects from the approximate positions he marked on a map of the ISA. For my study the positions of the four belt transects were located using permanent markers, or the distance along the road from a standardised starting point (SSP), or both. The SSP was chosen as the "NO ENTRY - PRIVATE ROAD" sign at Chobe Game Lodge. The locations of the four transects are shown in figure 2.2 (See Chapter 2). The details of the location of each transect are given in Appendix B. Starting from the eastern boundary of the ISA they comprised:

(i) Transect 1 - Crocodile Island transect,
(ii) Transect 2 - Nankanga Loop transect,
(iii) Transect 3 - Bushbuck drive transect,
(iv) Transect 4 - Rhino Pens transect.

3.2.1.4 Measurement of the structural features of the vegetation

As each belt transect was walked, two metre-long sticks were held parallel to the ground at waist height (1 metre), extending on either side of my body. For each woody plant species that the sticks came into contact with the following measurements were recorded:

(i) X co-ordinate (where the number of paces along the 0° bearing represented the X axis);

(ii) woody plant species;

(iii) stem number measured at ground level;

(iv) height of plant.

3.2.2 Vegetation change since 1969-1970

In 1969-1970 Simpson evaluated the structure and composition of the different vegetation types. He sampled a total of 79 ten foot square (3.05 m^2) quadrats over all the vegetation types in the intensive study area in December 1970. In addition he sampled four belt transects (1.82 m wide) through the intensive study area along a north-south bearing in approximately the same positions where I sampled mine. The vegetation change since Simpson's (1974) study was determined on a presence-absence basis by comparing the species composition recorded along the transects in 1969-1970 with the 1991 species composition.

3.2.3 Habitat preference of bushbuck

The vegetation types in the ISA were classified according to their woody species composition and their physiognomy (Simpson 1974, Somerlatte 1976). The locations of bushbuck within each vegetation type in the ISA were recorded during road counts. The monthly distribution of bushbuck was calculated for each vegetation type in the ISA. This was expressed as a percentage of the monthly totals in all the vegetation types.

The vegetation type in which the bushbuck was first seen (i.e. before it moved away) was recorded. The boundaries of each vegetation types along the road were marked on a map, then the length of road which each encompassed was measured using the odometer. The areas of each vegetation type sampled were determined using the effective visibility strip widths and the distance along the road each vegetation type covered. The method I used to estimate the effective strip width was an adaptation of the mean visibility method (Hahn 1949; Hirst 1969). An orange and white chequered board of bushbuck dimensions (0.8 by 1 m) was used to represent a bushbuck. The board was divided into twenty, 20 cm × 20 cm squares (See Appendix A). Instead of merely measuring the distance at which an object disappeared from view perpendicular to the road, I measured the distance from four directions around a mid point at which no squares on the board were fully visible. The effective strip width was estimated as the mean of these four values. The mean effective strip width was estimated for all the vegetation types in the ISA.

3.2.4 Vegetation factors associated with preference sites within the vegetation types

Previously Simpson (1974) examined vegetation factors such as proximity to water, canopy cover, lateral visibility and height of the vegetation in the different habitats. For the purposes of my study I decided it was more informative to examine the structural vegetation features at the sites where bushbuck were observed during the road and river counts ("presence" sites). It is the immediate surroundings that are of direct concern to the bushbuck. Additionally by looking at the same vegetation variables in adjacent sites (which I termed "absence" sites for convenience) I hoped to determine what features of the vegetation influenced bushbuck to choose a particular site and not the other one.

The vegetation factors thought to influence the daytime presence or absence of bushbuck were chosen subjectively by virtue of their relationship to specific vital functions such as feeding, thermoregulation and predator avoidance. The measurement of the vegetation factors was undertaken daily between 10:00 hours and 15:00 hours, between the times of the road and river counts and as close to the time of bushbuck observation as possible. The sites where each bushbuck was observed during the road and river counts were carefully defined at the time of observation (as outlined in Chapter 2) for the purpose of this subsequent vegetation sampling. A standard site size of 5 m radius around the position of the bushbuck was used for measuring the vegetation factors associated with its presence (Ferrar & Walker 1974).

The corresponding "absence" sites were located adjacent to the "presence" sites. The "absence" site was located by walking 20 paces along from the centre of the "presence" site parallel to the river. A coin was tossed at each "presence" site to determine whether the corresponding "absence" site was to be located east or west of the "presence" site. This reduced the possibility of any bias resulting from the researcher choosing in which direction to locate the "absence" site. A corresponding 5 m radius quadrat was used to measure the same vegetation factors within the "absence" sites.

To determine what structural aspects of the vegetation were important to the bushbuck, the following vegetation variables were estimated at each "presence" and corresponding "absence" site. It was decided that visual estimation was adequate for the needs of this study since the bushbuck themselves would have chosen the sites on their visual features.

3.2.4.1 *Canopy cover*

An 8 point scale (Anderson & Walker 1974) was used to estimate the degree of tree/shrub canopy cover associated with each site. The estimate was taken by standing at the exact location where the bushbuck was observed and looking directly upwards to estimate the canopy coverage. (e.g. when the bushbuck was seen under a shrub *Capparis tomentosa*, the canopy cover was taken as 100 %). Tree and shrub canopy cover were not distinguished as it was the overall shading effect that was being determined for each plot.

3.2.4.2 *Lateral visibility or screening effect of the vegetation*

The lateral visibility of the vegetation was estimated using a modified version of the board technique (Wight 1983). A lateral visibility index was estimated for each plot as discussed in Appendix A. The board of approximate bushbuck dimensions was positioned at the site where the bushbuck was observed and recordings were taken at 10 m distance looking back towards the board. As it was the screening effect of the vegetation that was being determined with regard to visibility for any potential predator, the number of squares visible at 10 m was measured from predator eye level (approximately 0.60 m, this was achieved by kneeling down).

The lateral visibility index ranged from 0 to 80 which corresponds to the total number of squares visible from four angles at 10 m distance from the board. A high index (80) indicates that the screening effect of the vegetation was low and lateral visibility was high. In contrast a low index value (0) implies that the screening effect of the vegetation was high, and lateral visibility was low.

3.2.4.3 *Association with woody species*

The different woody plant species within the 5 m radius plots were recorded. This was undertaken to determine whether bushbuck were associated with any particular woody plant species.

3.3 DATA ANALYSIS

3.3.1 Vegetation composition

3.3.1.1 *Vegetation types*

The mean height and mean number of stems were estimated for each different vegetation type. The Mann Whitney U test was used to determine whether there was any significant difference in the height and number of stems recorded in each transect between each vegetation type.

The density (woody plants over 1 m in height per hectare) was estimated for each different vegetation type. Additionally the density of each woody species was estimated within each vegetation type.

3.3.1.2 *Vegetation transects along the river front*

Bushbuck were more frequently seen in the section of the riparian fringe woodland east of Kalwizi during the river censuses (Chapter 2). The transects in the riparian fringe woodland were divided into those transects east and west of Kalwizi drainage (Transect number 28). Any differences in the species composition and diversity were examined between the east and west transects on a presence absence basis.

3.3.1.3 *Transects extending from the river to the southern boundary of the intensive study area*

The density of woody plants greater than 1 m in height (total plants per ha) was determined along each of the four transects. Additionally the density of the 10 most common species in the intensive study area was estimated from the four transects.

3.3.2 Vegetation change since 1969-1970

The species composition (as determined from the four transects which encompassed the whole spectrum of vegetation types) in the ISA for 1969-1970 and 1991 was compared on a presence absence basis. Additionally the order of species abundance from the four belt transects in 1969/1970 was compared to the 1991 order of species abundance.

3.3.3 Habitat preference

The habitat preference ratios (HPR's) were determined by taking into account the different strip widths between the dry months (July to October) and November when there had been a flush of growth in the vegetation. From these data the ratio of habitat utilisation to habitat availability was calculated for each month following the formula used by Petrides (1975) where:

Habitat Preference Ratio = U/A

where U = Utilisation = Uh/Ut

Uh = Number of observations in specific habitat.

Ut = Total number of observations in all habitats.

A = Availability = Ah/At

Ah = Area of specific habitat.

At = Total area of all habitats.

A logarithmic transformation of the habitat preference ratios was performed (Owen-Smith & Cooper 1987). Those vegetation types with positive values were considered preferred vegetation types whereas negative values indicated avoidance of the vegetation type.

Additionally the Neu method was used involving the performance of a chi-square overall goodness of fit test plus calculation of Bonferroni confidence limits for each component (Neu et al 1974). Thomas and Taylor (1990) state that the Chi Square goodness of fit test is the most commonly used statistical method for comparing resource use and availability. The Bonferroni z statistic creates confidence intervals (or 95% family confidence coefficients) around the observed values (Appendix C). By comparing the observed and expected values and the family confidence coefficients, it was verified whether observations occurred more than, less than or as expected within the vegetation types relative to their available areas. If the expected proportion lies outside the 95 % confidence intervals, there was a significant difference between the observed and expected number of bushbuck.

The procedures of data collection must be such that animals that are studied have access to and opportunity to be observed in the various vegetation types (Byers & Steinhorst 1984). The Neu method assumes that each observation is independent of every other observation (Aldredge & Ratti 1990). Bushbuck are not herd animals and were seen alone or as a mother with her young lamb on most occasions. The data were analyzed using the number of sightings (i.e. mother + young = 1 sighting), rather than the number of bushbuck observed.

Simpson (1974) reported habitat preferences by bushbuck in his intensive study area and ranked the habitats in order of preference. I compared his relative ranking in 1969/70 with that determined in the present study .

3.3.4 Vegetation factors associated with preference sites within the different vegetation types

The non-parametric Mann-Whitney U test was used to determine whether there was a significant difference between the "presence" and "absence" sites for each of the vegetation factors recorded.

3.3.5 Bushbuck activity at preference sites and the vegetation factors associated with these sites

For each of the sites where bushbuck activities (feeding, resting and walking) were recorded the vegetation factors were examined.

3.4 RESULTS

3.4.1 Current composition of vegetation

3.4.1.1 *Vegetation types*

The physiognomic characteristics of the 5 vegetation types are shown in Table 3.1. The riparian fringe woodland had the highest mean vegetation height and richest species composition compared to the other vegetation types. In 1969/70 Simpson (1974) reported that the mean vegetation height in the riparian forest fringe was 7.4 m, but no confidence limits were given. It would appear that in general the mean vegetation height in the different vegetation types was lower in 1991 than in 1969/70 (Table 3.1).

Croton-Capparis shrubland had a relatively poor species composition compared to the other vegetation types. This vegetation type was dominated by *Croton megalobotrys, Capparis tomentosa* and *Combretum mossambicense* (Table 3.2). The *Capparis tomentosa* was widespread and appeared to scramble over dead plants. An area around the old dip tank in the western end of the ISA was dominated by *Dichrostachys cinerea* thickets in 1969/1970. In 1991 the area was dominated by *Capparis tomentosa* clumps that had engulfed the *Dichrostachys cinerea* thickets.

Croton megalobotrys was the most common species in the *Acacia* woodland and *Croton-Capparis* shrubland. The *Acacia* woodland was characterised by a few *Acacia nigrescens, Acacia erioloba* and *Berchemia discolor* trees, some with ring barking damage evident (Table 3.2). Dead *Acacia tortilis, Acacia erioloba* and *Berchemia discolor* were scattered through this vegetation type.

The species of greatest height were not present in enough numbers to influence the overall height of the vegetation in any of the vegetation types. In general the vegetation types appeared to be quite thicket-like in nature. In the *Croton-Capparis* shrubland and the *Acacia* woodland the presence of multistemmed species such as *Capparis tomentosa, Securinega virosa, Canthium frangula* and *Dichrostachys cinerea* contributed to the thicket-like nature of the vegetation. In the *Combretum-Baphia* shrubland and *Combretum-Dichrostachys* thicket the high plant density contributed to the thicket-like nature of these vegetation types.

Table 3.1: Physiognomic vegetation features recorded for 5 vegetation types in the intensive study area

	VEGETATION TYPES IN INTENSIVE STUDY AREA				
	RIPARIAN FRINGE WOODLAND	*CROTON-CAPPARIS* SHRUBLAND	*COMBRETUM-BAPHIA* SHRUBLAND	*ACACIA* WOODLAND	*COMBRETUM-DICHROSTACHYS* THICKET
NO.OF TRANSECTS	10	10	10	10	10
TRANSECT LENGTH (m)	500	500	500	551	500
TOTAL NUMBER OF WOODY SPECIES	21	9	16	17	12
1991 VEGETATION HEIGHT mean (sd)	3.4 (4.1)	2.2 (1.2)	1.2 (0.6)	1.9 (2.0)	1.5 (0.9)
1969/70 VEGETATION HEIGHT mean	7.4	0	2.0	4.6	2.9
NUMBER OF STEMS PER PLANT mean (sd)	3.2 (4.1)	4.4 (5.2)	3.0 (1.7)	4.4 (4.7)	4.0 (3.9)
TOTAL NUMBER OF WOODY PLANTS	215	208	334	238	285
DENSITY (per ha)	2150	2080	3340	2160	2850

Table 3.2: Density (plants per hectare) calculated for the 11 most common plant species recorded in the 5 vegetation types, which covered an area of 1102 m^2 in the intensive study area.

SPECIES	VEGETATION TYPES IN THE INTENSIVE STUDY AREA				
	RIPARIAN FRINGE WOODLAND	*CROTON-CAPPARIS* SHRUBLAND	*COMBRETUM- BAPHIA* SHRUBLAND	*ACACIA* WOODLAND	*COMBRETUM-DICHROSTACHYS* THICKET
COMBRETUM MOSSAMBICENSE	280	620	345	355	340
BAPHIA MASSAIENSIS	0	0	1670	65	400
CROTON MEGALOBOTRYS	320	920	40	565	30
COMBRETUM ELAEAGNOIDES	120	20	580	535	340
DICHROSTACHYS CINEREA	540	0	155	25	710
CANTHIUM FRANGULA	210	170	20	320	150
MARKHAMIA ACUMINATA	70	30	215	55	180
CAPPARIS TOMENTOSA	50	240	0	0	0
STRYCHNOS POTATORUM	130	20	0	55	80
SECURINEGA VIROSA	80	30	0	45	10
FRIESODIELSIA OBOVATA	30	0	60	45	0
OTHER SPECIES	320	30	255	295	70
WOODY PLANT DENSITY (plants per ha)	2150	2080	3400	2160	2850

3.4.1.2 *Vegetation transects along the river front*

Seventeen transects were sampled east of Kalwizi valley and 27 transects were sampled west of it in the riparian fringe woodland. The vegetation in the transects east of Kalwizi was significantly taller than those to the west (Mann-Whitney $U = 324.5$; $p < 0.05$) (Table 3.3). No significant difference was evident for the number of stems per plant (Mann-Whitney $U = 244$; $p > 0.05$).

The riparian fringe situated east of Kalwizi valley had more tall trees which formed a closed canopy compared to the riparian fringe west of Kalwizi. The area of the riparian fringe east of Kalwizi was mostly on the steep slope of the high flood line. The tree species identified along the steeper slopes included *Acacia nigrescens, Trichilia emetica, Garcinia livingstonei, Croton megalobotrys, Strychnos potatorum* and *Diospyros mespilliformis.* In the more open areas west of Kalwizi a few relic trees remained (*Trichelia emetica, Loncocarpus capassa* and *Croton megalobotrys*) as well as some dead *Acacia spp.*

Table 3.3: Woody vegetation factors recorded in transects sampled east and west of Kalwizi valley in the riparian fringe woodland. Figures represent the mean value, standard deviation in brackets

	TRANSECTS WEST OF KALWIZI	TRANSECTS EAST OF KALWIZI
HEIGHT MEAN	2.5 (0.7)	3.1 (0.9)
NUMBER OF STEMS PER PLANT MEAN PER TRANSECT	4.8 (2.5)	4.9 (2.2)
NUMBER OF SPECIES MEAN PER TRANSECT	4.4 (1.5)	6.9 (2.6)
DENSITY (PER ha)	1127	1423
NUMBER OF TRANSECTS	27	17

3.4.1.3 *Transects extending from the rivers edge to the southern limit of the intensive study area*

In 1991 the mean vegetation height from the four transects was 1.6 m (± 0.07). Simpson's (1974) results from the four transects in 1969/70 showed that the mean vegetation height in the intensive study area was 2.8 m. (no confidence limits were given). The vegetation in the ISA appears to be lower in 1991 compared to 1970 (Table 3.4).

Table 3.4: Physiognomic vegetation features of the woody plants measured along the 4 belt transects extending through the Intensive study area

TRANSECT	CROCODILE ISLAND	NANKANGA LOOP	BBUCK DRIVE	RHINO PENS	OVERALL	
LENGTH (m)	474	295	524	902	2195	
HEIGHT OF WOODY PLANTS mean (sd)	1.4 (1.0)	1.1 (0.7)	2.0 (1.2)	1.8 (1.0)	1.6 (1.0)	
NUMBER OF STEMS PER PLANT mean (sd)	4.2 (3.1)	3.3 (2.2)	4.5 (5.1)	4.4 (3.4)	4.1 (3.6)	
DENSITY (woody plants per ha) OF THE 10 MOST COMMON WOODY PLANT SPECIES					TOTAL NUMBER OF PLANTS	SPECIES DENSITY (per ha)
COMBRETUM MOSSAMBICENSE	306	186	697	931	281	640
BAPHIA MASSAIENSIS	549	898	57	39	118	269
CROTON MEGALOBOTRYS	53	51	458	272	105	239
COMBRETUM ELAEAGNOIDES	274	593	105	122	94	214
DICHROSTACHYS CINEREA	570	119	10	105	81	185
MARKHAMIA ACUMINATA	232	203	29	22	41	93
CANTHIUM FRANGULA	127	85	181	0	36	82
CAPPARIS TOMENTOSA	21	0	19	139	29	66
SECURINEGA VIROSA	0	34	38	116	27	62
STRYCHNOS POTATORUM	0	0	47	72	18	41
OTHER SPECIES	190	288	10	155		
TOTAL NUMBER OF PLANTS	220	145	173	356	1280	
DENSITY (PER Ha)	2321	2458	1651	1973		2916

3.4.2 Vegetation change since 1969-1970

The species recorded along 4 belt transects through the ISA were ranked in order of their abundance. All the *Combretum spp* including *Combretum mossambicense* and *Combretum elaeagnoides* were lumped into the *Combretum spp* classification. This was also done by Simpson (1974) for the 4 belt transects which traversed the ISA in 1970 (Table 3.5). In 1969/1970 *Baphia massaiensis* was the most abundant woody species. In 1991 the *Combretum spp.* were the most abundant species. *Combretum mossambicense* was the most abundant species recorded in 1991. *Croton megalobotrys*, which was the fourth most abundant species in 1991, was only ranked 10th in 1970. In 1991 *Capparis tomentosa, Markhamia acuminata* and *Strychnos potatorum* were amongst the 10 most abundant species. They were not mentioned by Simpson amongst the 15 most abundant species recorded in 1970. In 1991 *Bauhinia macrantha, Commiphora pyacanthoides, Ximenia americana, Rhus tenuinervis* and *Ziziphus mucronata* recorded by Simpson (1974) were not recorded (Table 3.5).

3.4.3 Habitat preference

The habitat preference ratios (HPR) indicate that riparian fringe vegetation ranked highest. *Croton-Capparis* shrubland was the next preferred, followed by *Combretum-Baphia* shrubland. The *Combretum-Dichrostachys* thickets, *Acacia* woodland and the mixed ecotone complex appeared to be avoided by the bushbuck (Table 3.6). During the dry months of July to September the riparian fringe and *Croton-Capparis* shrubland were consistently preferred vegetation types. From September to November *Combretum-Baphia* shrubland was favoured. In November *Combretum-Baphia* shrubland had the highest HPR value and the riparian fringe was placed second in the preference ranking.

Table 3.5: Abundance ranking of the 15 most common woody species recorded along 4 belt transects in the intensive study area for 1969/70 and 1991

SPECIES	1969/70 SIMPSONS STUDY	1991 PRESENT STUDY
BAPHIA MASSAIENSIS	1	3
COMBRETUM SPP.	2	1
DICHROSTACHYS CINEREA	3	6
CANTHIUM FRANGULA	4	8
ACACIA SCHWEINFURTHII	5	14
BAUHINIA MACRANTHA	6	0
COMMIPHORA PYACANTHOIDES	7	0
COMBRETUM MOSSAMBICENSE	8	2
XIMENIA AMERICANA	9	0
CROTON MEGALOBOTRYS	10	4
SECURINEGA VIROSA	11	10
COMBRETUM ELAEAGNOIDES	12	5
RHUS TENUINERVIS	13	0
ACACIA NIGRESCENS	14	15
ZIZIPHUS MUCRONATA	15	0
MARKAMIA ACUMINATA	0	7
CAPPARIS TOMENTOSA	0	9
STRYCHNOS POTATORUM	0	11
GUIBOURTIA COLEOSPERMA	0	12
BERCHEMIA DISCOLOR	0	13

Table 3.6: Habitat preference ratios of bushbuck in the intensive study area, expressed on a logarithmic scale. Total bushbuck sightings are in parentheses.

MONTH	HABITAT PREFERENCE RATIOS					
	RIPARIAN FRINGE WOODLAND	*CROTON-CAPPARIS* SHRUBLAND	*COMBRETUM-BAPHIA* SHRUBLAND	*ACACIA* WOODLAND	*COMBRETUM-DICHROSTACHYS* THICKET	MIXED ECOTONE
JULY	0.83 * (7)	0.34 (9)	-0.10 (4)	-0.59 (3)	-0.24 (1)	0.00 (0)
AUGUST	0.78 * (12)	0.41 (20)	-0.49 (3)	-0.39 (9)	-0.52 (1)	0.00 (0)
SEPTEMBER	0.65 * (7)	0.44 (17)	0.03 (8)	-0.77 (3)	-0.42 (1)	0.00 (0)
OCTOBER	0.48 * (5)	-0.04 (6)	0.33 (17)	-0.37 (8)	-0.14 (2)	0.00 (0)
NOVEMBER	0.16 (3)	-0.21 (4)	0.29 * (14)	-0.11 (13)	-0.44 (1)	0.16 (1)
TOTAL	0.64 (34)	0.26 (56)	0.09 (46)	-0.39 (36)	-0.34 (6)	-0.53 (1)

* indicates the vegetation type that is top of the order of preference for the month.

Table 3.7: Relative sightings of bushbuck in 6 vegetation types over the 5 month study period.

VEGETATION TYPE	AREA SAMPLED (ha)	PROPORTION OF AREA	NUMBER OF SIGHTINGS	EXPECTED NUMBER OF SIGHTINGS	OBSERVED PROPORTION OF USEAGE	χ^2 VALUE	95% FAMILY CONFIDENCE COEFFICIENT
RIPARIAN FRINGE WOODLAND	1.50	0.044	34	7.9	0.189	86.2	$0.111 \leq p \leq 0.263$
CROTON-CAPPARIS SHRUBLAND	5.85	0.172	56	30.8	0.313	20.6	$0.211 \leq p \leq 0.404$
COMBRETUM-BAPHIA SHRUBLAND	7.10	0.208	46	37.2	0.257	2.1	$0.171 \leq p \leq 0.343$
ACACIA WOODLAND	16.65	0.488	36	87.4	0.201	30.2	$0.122 \leq p \leq 0.280$
COMBRETUM-DICHROSTACHYS THICKET	2.50	0.073	6	13.1	0.034	3.8	$-0.003 \leq p \leq 0.070$
MIXED ECOTONE	0.50	0.015	1	2.7	0.006	1.1	$-0.009 \leq p \leq 0.020$
TOTALS	34.10	1.000	179	179	1.000	144	

(χ^2 = 144 df = 5, $P < 0.001$)

The Chi-squared goodness of fit test confirmed that bushbuck generally favoured riparian fringe woodland and *Croton-Capparis* shrubland, whereas the *Acacia* woodland and the mixed ecotone were avoided (Table 3.7).

Analysis of the monthly data showed that in July the riparian fringe was the significantly preferred vegetation type. In August *Croton-Capparis* shrubland also became significantly preferred by the bushbuck, while *Acacia* woodland was significantly avoided in this month. In September *Croton-Capparis* shrubland was the only significantly preferred vegetation type. In October *Combretum-Baphia* shrubland was the only significantly preferred vegetation type. By November there was no significant vegetation type preference exhibited by the bushbuck (Table 3.8).

Table 3.8: Monthly habitat preferences expressed as positively (+) or negatively (-) significant

VEGETATION TYPE	MONTH				
	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER
RIPARIAN FRINGE WOODLAND	+	+	0	0	0
CROTON-CAPPARIS SHRUBLAND	0	+	+	0	0
COMBRETUM-BAPHIA SHRUBLAND	0	–	0	+	0
ACACIA WOODLAND	–	–	–	–	0
COMBRETUM-DICHROSTACHYS THICKET	0	0	0	0	0
MIXED ECOTONE	0	0	0	0	0

3.4.4 Vegetation factors associated with preference sites within the vegetation types

During the study period 331 "presence" and 331 adjacent "absence" sites were sampled and the vegetation variables were measured for each site. The sites were divided into sites where bushbuck were seen feeding, walking and resting. Bushbuck were recorded feeding at 157 sites, walking at 43 sites, resting at 121 sites, drinking at 5 sites and grooming at 5 sites.

3:4:4:1 *Canopy cover*

There was no significant difference between the canopy cover recorded at sites where bushbuck were seen feeding and walking so these categories were lumped together for analysis (Mann Whitney $U = 3224$; $p > 0.05$; $df = 199$). There was a significant difference in the canopy cover recorded at sites where bushbuck were seen resting and feeding (Mann Whitney $U = 6832$ $p < 0.001$; $df = 277$), and resting and walking (Mann Whitney $U = 3169$ $p < 0.001$; $df = 163$).

Bushbuck were seen feeding and walking most frequently at sites where canopy cover was low (0%) (Figure 3.1). At the 200 sites involved the canopy cover was significantly higher than at the 200 corresponding "absence" sites (Mann Whitney $U = 30937$ $p < 0.001$; $df = 200$).

Bushbuck were seen resting most frequently at sites which provided total (100%) canopy cover (Figure 3.2). At the 121 sites where bushbuck were seen resting the canopy cover was significantly higher than at the 121 corresponding "absence" sites (Mann Whitney $U = 12691p < 0.001$; $df = 143$).

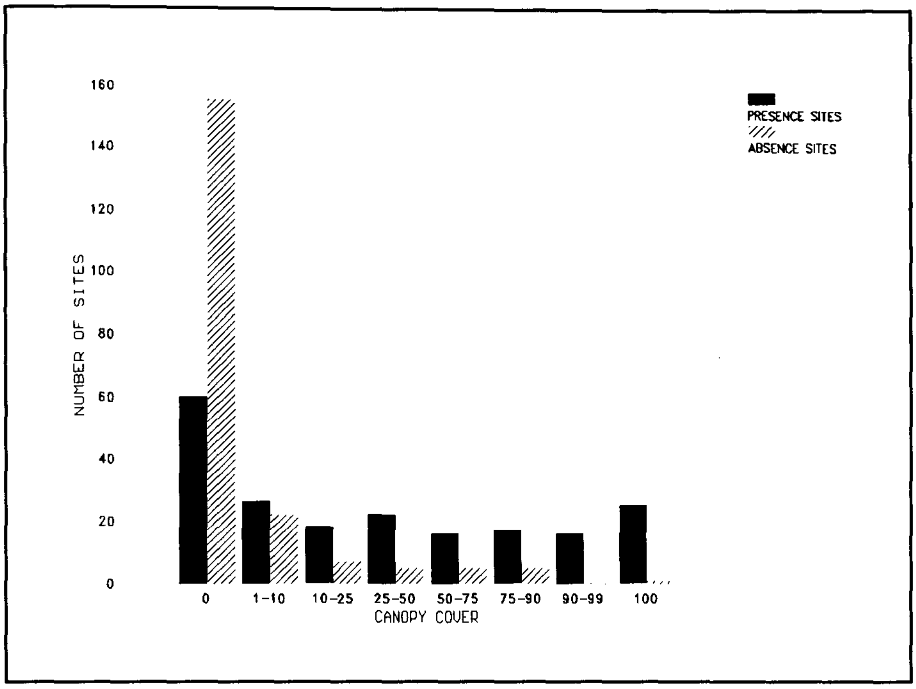

Figure 3.1: Canopy cover recorded for 200 sites where bushbuck were seen feeding or walking and for the 200 corresponding absence sites

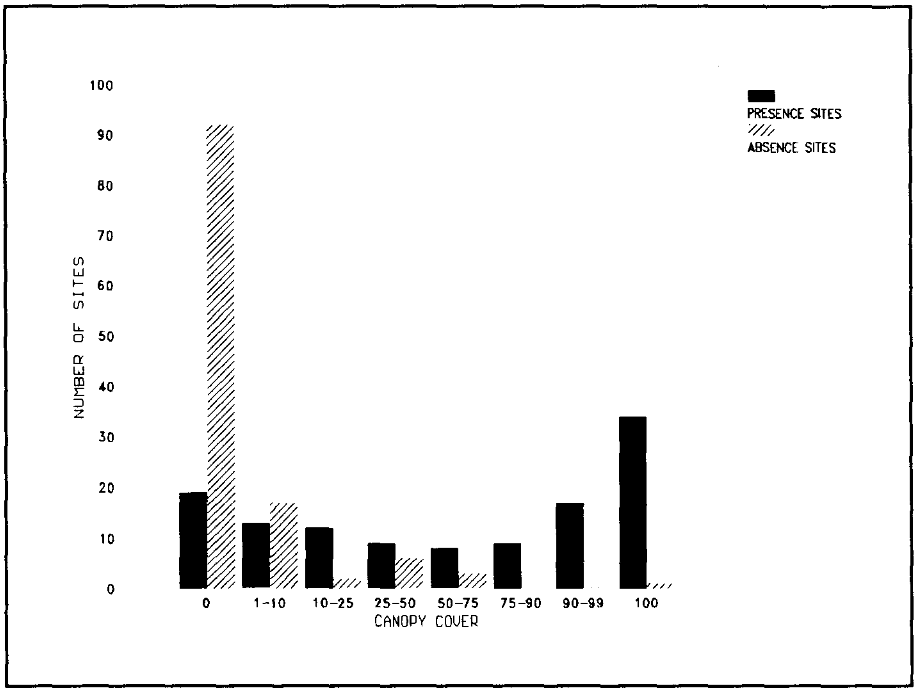

Figure 3.2: Canopy cover recorded for 121 sites where bushbuck were resting and for 121 corresponding absence sites

3.4.4.2 *Lateral visibility*

There was no significant difference between the lateral visibility recorded at sites where bushbuck were seen feeding and walking so these categories were clumped together for analysis (Mann Whitney U = 3188 $p > 0.05$; df = 199). There was a significant difference in the lateral visibility recorded at sites where bushbuck were seen resting and feeding (Mann Whitney U = 12679 $p < 0.001$; df = 277), and resting and walking (Mann Whitney U = 1681 $p < 0.001$; df = 163).

Bushbuck were seen feeding and walking most frequently at sites where lateral visibility was low (i.e., where the lateral visibility index was 20 or less) (Figure 3.3). The 200 sites where bushbuck were seen feeding and walking had significantly lower lateral visibility than the 200 corresponding "absence" sites (Mann Whitney U = 5953; $p < 0.001$; df = 199).

Bushbuck were seen resting most frequently at sites where lateral visibility was low. Eighty-two percent of the sites where bushbuck were seen resting had a lateral visibility index less than 20. Bushbuck were seldomly seen resting at sites where lateral visibility was high (Figure 3.4). The 121 resting sites had significantly lower lateral visibility compared to the 121 corresponding "absence" sites ((Mann Whitney U = 1141 $p < 0.001$; df = 199).

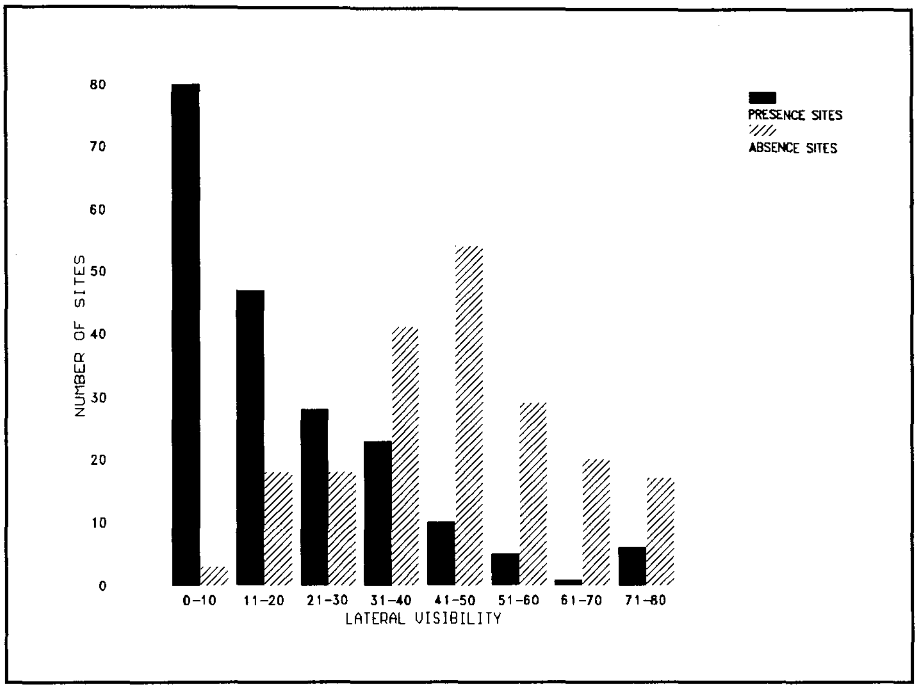

Figure 3.3: Lateral visibility recorded at 200 sites where bushbuck were feeding or walking and for the 200 corresponding absence sites

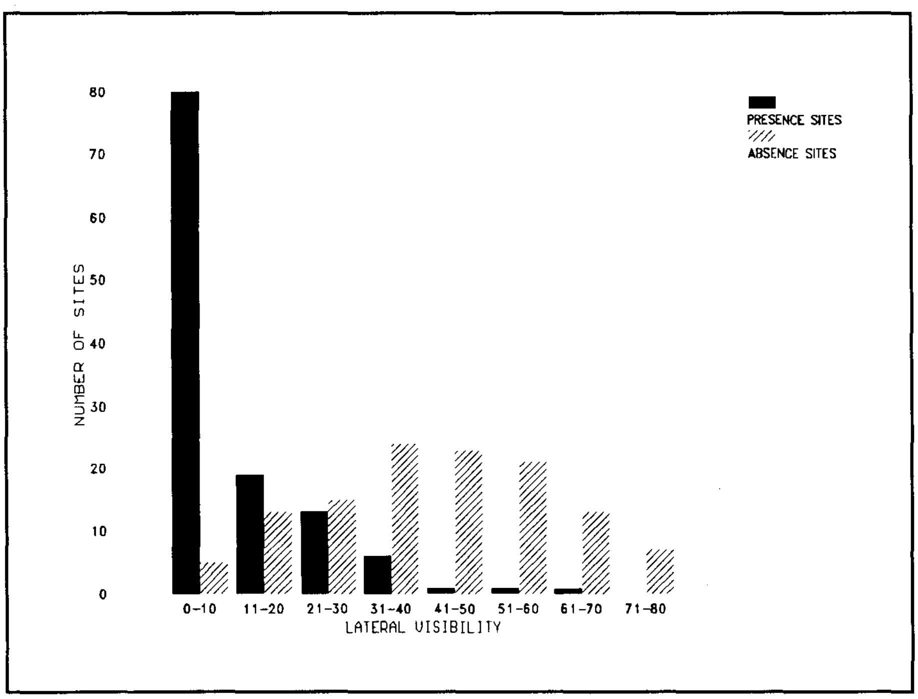

Figure 3.4: Lateral visibility recorded at 121 sites where bushbuck were resting and for 121 corresponding absence sites

3.4.4.3 *Association with woody plant species*

The woody species which were recorded in at least 25 different plots for both the 331 "presence" and the 331 "absence" plots are presented in Table 3.9. *Capparis tomentosa* was the most frequently recorded woody species and *Croton megalobotrys* was the second most frequent at the sites where bushbuck were observed.

Table 3.9: The 15 most common woody species recorded at sites where bushbuck were seen feeding, walking and resting (the percentage of total sites for each activity are shown in parentheses).

SPECIES	ACTIVITY		
	FEEDING	RESTING	WALKING
CAPPARIS TOMENTOSA	110 (70 %)	98 (81%)	32 (74%)
CROTON MEGALOBOTRYS	90 (57%)	81 (67%)	24 (56%)
DICHROSTACHYS CINEREA	47 (30%)	22 (18%)	5 (12%)
COMBRETUM MOSSAMBICENSE	33 (21%)	31 (26%)	9 (21%)
SECURINEGA VIROSA	31 (20%)	36 (30%)	15 (35%)
TRICHILIA EMETICA	28 (18%)	14 (12%)	8 (19%)
COMBRETUM ELAEAGNOIDES	25 (16%)	16 (13%)	3 (7%)
CANTHIUM FRANGULA	24 (15%)	15 (12%)	2 (5%)
ACACIA NIGRESCENS	22 (14%)	12 (10%)	2 (5%)
BAPHIA MASSAIENSIS	18 (11%)	9 (7%)	2 (5%)
STRYCHNOS POTATORUM	16 (10%)	7 (6%)	3 (7%)
ACACIA SCHWEINFURTHII	12 (8%)	9 (7%)	7 (16%)
ACACIA ERIOLOBA	11 (7%)	5 (4%)	4 (9%)
DIOSPYROS MESPILLIFORMIS	10 (6%)	13 (11%)	5 (12%)
GARCINIA LIVINGSTONEI	8 (5%)	6 (5%)	3 (7%)

Dichrostachys cinerea was the third most common woody species recorded in sites where bushbuck were seen feeding. *Dichrostachys cinerea* was not among the top 5 most common species recorded at sites where bushbuck were seen walking.

During my study bushbuck were commonly observed feeding on the leaves of *Capparis tomentosa, Securinega virosa, Combretum spp.* and *Dichrostachys cinerea.* These species were all among the top 5 most common woody species recorded at sites where bushbuck were seen feeding (Table 3.9). At the height of the dry season (September/October) fallen leaves from *Strychnos potatorum, Trichelia emetica* and *Acacia nigrescens* were eaten by the bushbuck. Fallen fruit from *Garcinia livingstonei, Strychnos potatorum* and *Trichelia emetica* were also taken. On 3 separate occasions bushbuck were seen to feed on *Garcinia livingstonei* fruit that baboons had knocked down during their foraging. On several occasions one juvenile bushbuck was observed to eat seeds from *Combretum* spp. He carefully selected the seeds from amongst the ground leaf litter (pers obs.). There was 4 separate recordings of bushbuck feeding on baboon dung at the end of the dry season (October) when food resources were scarce.

3.5 DISCUSSION

There appears to have been a change in the vegetation along the Chobe river front since 1969/1970. It appears that by 1991 the vegetation in the ISA had fewer tall trees compared to 21 years ago. The loss of tall trees was most obvious in the *Acacia* woodland where dead *Acacia tortilis, Acacia erioloba* and *Berchemia discolor* were widely. Sommerlatte (1976) found that damage to the *Acacia* woodland vegetation was worse than in other vegetation types along the river front. Parry (1989) reported that the decline in canopy cover in the *Acacia* woodland had been more severe between 1973 and 1985 compared to the previous 10 years.

More tall trees remained in the section of riparian fringe woodland east of Kalwizi valley compared to the western section. This suggests that vegetation change was more advanced in the western section. Simpson (1974) reported that the least damaged area of the riparian fringe vegetation was confined to the steep slopes of the high flood line. This was still the situation in 1991.

The *Croton-Capparis* shrubland was not identified in Simpson's (1974) study. In 1991 this vegetation type probably represented an advanced stage in the vegetation change resulting from heavy utilisation of *Acacia* woodland by elephant. The umbrella-like clumps of *Capparis tomentosa* offered good hiding places for small animals such as bushbuck. The multistemmed nature of some of the *Croton megalobotrys* trees provided good lateral cover for the bushbuck.

The removal of the tall trees promoted the growth of woody species that had previously constituted the lower canopy vegetation. In *Croton-Capparis* shrubland, riparian fringe woodland and *Acacia* woodland, species such as *Croton megalobotrys* and *Strychnos potatorum* had become part of the upper canopy component by 1991. *Combretum elaeagnoides, Combretum mossambicense* and *Markhamia acuminata* had become more common by 1991 in all the vegetation types. *Capparis tomentosa* had become more common in the riparian fringe woodland and *Croton-Capparis* shrubland, which were the two preferred vegetation types in the dry season.

The more thicket-like nature of the vegetation in the ISA could be attributed to the multistemmed shrubs such as *Capparis tomentosa, Canthium frangula* and *Securinega virosa*. Areas that had been dominated by pure stands of *Dichrostachys cinerea* in 1969/70 had become dominated by *Capparis tomentosa* clumps by 1991.

HABITAT PREFERENCE

Bushbuck distribution and habitat preference determined during this study only apply to the times of the day in which the censuses took place (i.e.; early mornings and evenings). It was not within the scope of the present study to determine the nocturnal distribution of bushbuck. The results indicated that over the 5 month study period the riparian fringe woodland was the most preferred vegetation type, as had been reported by Child (1968) and Simpson (1974).

Croton-Capparis shrubland was favoured in August and September when vegetation types further away from the river were bare. *Croton megalobotrys* and *Capparis tomentosa* still had green foliage and therefore provided lateral cover and food. Along the Mweya peninsula in Uganda, bushbuck were found to prefer *Capparis tomentosa* thickets during the day (Waser 1975, Okiria 1980). Previous studies have mentioned the importance of *Capparis tomentosa* as a food resource for bushbuck (Simpson 1974; Okiria 1980) and for concealment purposes (Waser 1975; Okiria 1980).

The *Acacia* woodland was avoided by bushbuck during the dry season months until November. The open nature of the vegetation provided little lateral cover. *Dichrostachys cinerea* was usually one of the last species to flower and produce leaves (Simpson 1974). This could explain why bushbuck avoided this vegetation type during the earlier months.

In October *Combretum-Baphia* shrubland provided good lateral cover, at a time of the year when lateral cover was low in other vegetation types. By the end of October after the first showers, the flush of growth of leaves and shoots was evident in the *Combretum-Baphia* shrubland. *Baphia massaiensis* was in flower and bushbuck fed on the new leaves and shoots as well as the abundant seeds of the *Combretum spp.* Simpson (1974) reported that *Combretum-Baphia* shrubland was the second most preferred vegetation type after riparian forest fringe woodland. The present study shows that this vegetation type remained important to the bushbuck along the Chobe river front.

VEGETATION FACTORS ASSOCIATED WITH BUSHBUCK ACTIVITY AT SITES WITHIN THE VEGETATION TYPES

In general, bushbuck preferred sites which provided higher canopy cover than was afforded in adjacent sites for feeding, walking and resting. They favoured sites which provided total canopy cover (100%) when they were resting (which included lying and standing). This was the time when rumination usually took place. Shade provided by the total canopy cover would be important to bushbuck resting during the day.

Bushbuck tended to prefer sites which had low canopy cover when they were feeding and walking. Thompson (1972) found that they favoured areas which provided good canopy cover in *Baikaea plurijuga* woodland in Victoria Falls National Park, Zimbabwe. By contrast Simpson (1974) found that the removal of the upper canopy in *Baikaea plurijuga* woodland in Chobe National Park did not affect the overall choice of this vegetation type by bushbuck.

In my study lateral visibility or the screening affect of the vegetation appeared to be an important factor influencing the presence of bushbuck. They generally favoured sites which provided low lateral visibility whatever activity they were engaged in. In some instances bushbuck were seen feeding and walking in sites which provided high lateral visibility but they were seldomly seen resting there. Waser (1975), Okiria (1980) and Allen-Rowlandson (1986) are in agreement that bushbuck prefer areas of low lateral visibility during the day.

Lateral cover is probably important mainly for purposes of concealment. Bushbuck are not reputed to rely on speed for predator avoidance, instead they bolt to a nearby thicket and freeze. Waser (1975) and Okiria (1980) report that they hide in *Capparis tomentosa* thickets during the day in Rwenzori National Park, Uganda, and suggest that this behaviour is a predator avoidance tactic.

Bushbuck appeared to favour sites where *Capparis tomentosa* and *Croton megalobotrys* were present whatever activity they were involved in. (Simpson 1974) reported that *Capparis tomentosa, Securinega virosa, Combretum mossambicense* and *Dichrostachys cinerea* were favoured food plants. In this study they featured amongst the top five most common species at sites where bushbuck were observed. Preferred resting sites which provided both total canopy cover and low lateral visibility were provided by *Capparis tomentosa*, *Croton megalobotrys* and *Securinega virosa*. The dome shaped *Capparis tomentosa* clumps provided good hiding places. A variety of grasses, forbs and saplings are found at the bases of these clumps (Waser 1975), providing a food resource.

Generally bushbuck were found in sites within vegetation types where there was a best combination of factors. The activity which the bushbuck was engaged in determined which factor (canopy cover or lateral cover) was more important. In general bushbuck preferred sites where lateral visibility was low. The combination of low canopy cover and high lateral visibility made adjacent sites less attractive.

CONCLUSIONS

Over the 21 years the loss of tall trees in the intensive study area was evidence that vegetation change had taken place. This had been more extensive in some vegetation types, such as the *Acacia* woodland than in others . Dead *Acacia spp.* were scattered throughout this vegetation type. *Croton-Capparis* shrubland, classified in 1991 but not recognised in 1969/70, probably represented areas of *Acacia* woodland where vegetation change was at an advanced stage.

In the dry season months when other vegetation types were bare of foliage, the riparian fringe woodland and *Croton-Capparis* shrubland provided better lateral visibility and canopy cover for concealment for the bushbuck during the day. By November, when bushbuck showed no signs of habitat preference, lateral visibility was low in most vegetation types.

Bushbuck persisted in spatially isolated pockets of favourable vegetation types. As numbers declined with the opening up of the vegetation, they may have become more susceptible to predation and poaching. In areas where this spatial isolation was extreme, as in the western region, there may not have been any movement of bushbuck between pockets to recolonise these areas following poaching or predation.

CHAPTER 4

4.0: OVERVIEW AND MANAGEMENT IMPLICATIONS

Vegetation along the Chobe river has been subjected to various land uses over the last century (Simpson 1974). They have included fire and human interference.

Bushbuck numbers have declined along the Chobe river front since 1969/70. The animals have persisted in spatially separated pockets of favourable vegetation types, but at lower levels than in the past. In the western region of the Chobe river front the decline was severe.

In the intensive study area bushbuck preferred riparian fringe woodland and *Croton-Capparis* shrubland during the dry season months. In some areas *Capparis tomentosa* clumps dominated the vegetation, probably where elephant induced vegetation change was extreme. They were favoured by bushbuck as the dome-shaped clumps afforded good lateral and canopy cover during the day.

Steep areas along the river front provided the best combination of lateral cover, canopy cover and food species for bushbuck. Results from this study suggest that bushbuck will persist at current levels in the riparian margin and adjacent *Croton-Capparis* shrubland.

The issue of culling elephant to reduce the dry season pressure on the riverine vegetation has been raised by previous researchers (Child 1968; Sommerlatte 1976; Moroka 1985; Melton 1986; Work 1986). Culling of elephant in areas adjacent to the park may however compound the pressure on the vegetation communities along the river frontage (Work & Owen-Smith 1986). Vegetation change has already occurred along the Chobe river front and culling of elephant would not improve the status of the bushbuck. In Kruger National Park, South Africa, vegetation change perceived as being detrimental has not been prevented by keeping elephant at relatively low levels (Viljoen 1988). In

Ruaha National Park, Tanzania, Barnes (1979) reported that to allow for recovery of damaged woodland, it would be necessary to remove over 75% of the elephant population. The reduction of elephant to such a degree would have serious repercussions on the Chobe National Park as a tourist attraction (Work & Owen-Smith 1986). The eastern river frontage is heavily utilised by tourists. Any form of disturbance culling along the river front to redistribute the elephant would have unfavourable consequences for the tourism industry.

The reason for lack of bushbuck in areas towards Ihaha in the western region of the park requires further research. The areas consist of pockets of dense vegetation and thickets which extend to the rivers edge and appeared to provide good lateral cover. Tall trees also provide good canopy cover. So why where bushbuck absent from these areas? Had poaching had a detrimental effect on populations here? More research including a more detailed vegetation analysis is needed to determine the similarity and differences in these vegetation pockets along the western river frontage. In addition more research is required to examine the possibility that the western pockets of suitable bushbuck habitat are too isolated for recolonisation.

CONCLUSIONS

(1) There has been a decline in the bushbuck population along the Chobe river front since 1969/1970. The extent of the decline shows a degree of spatial variation. In pockets of favourable habitat numbers have declined to about one third (between 24% and 43%) of the 1969/70 level. In the western section of the Chobe river front the bushbuck population had dropped drastically to only 2% of the former level.

(2) Vegetation change as a result of utilisation by elephant was shown by dead trees especially *Acacia spp. Croton-Capparis* shrubland, not recorded in 1969/70 has become widespread. Clumps of *Capparis tomentosa* and *Croton megalobotrys* shrubs and trees provide lateral and canopy cover for the bushbuck.

(3) Bushbuck favoured riparian fringe woodland and *Croton-Capparis* shrubland in the dry season months from July to September. In October they favoured the *Combretum-Baphia* shrubland. By November, once there had been a flush of growth in the vegetation, no clear habitat preference was exhibited. *Acacia* woodland was seldom used until November.

(4) Bushbuck are likely to persist at their current levels in the riparian margin and the adjacent *Croton-Capparis* shrubland.

CHAPTER 5

5.0: REFERENCES

Aldredge, J.R & Ratti, J.T. 1990. Further comparison of some statistical techniques for analysis of resource selection. *J. Wild. Mgmt.* **56(1)**:1-9.

Allen-Rowlandson, T. 1986. An autecological study of the bushbuck and the common duiker in relation to forest management. PhD thesis. University of Natal.

Allsopp, R. 1978. Social biology of the bushbuck (*Tragelaphus scriptus ornatus* Pallas 1776) in the Nairobi National Park, Kenya. *E. Afr. Wildl. J* **16:**153-165.

Anderson, D.R. & Pospahala, R.S. 1970. Correction of bias in belt transect studies of immotile objects. *J. Wild. Mgmt.* **34(1):**141-146.

Anderson, D.R & Walker, B.H. 1974. Vegetation composition and elephant damage in the Sengwa wildlife research area, Rhodesia. *J. Sth. Afr. Wildl. Mgmt. Ass.* **4:**1-14.

Anderson, J.L. 1979. Reproductive seasonality of the nyala (*Tragelephus angasi*); the interaction of light vegetation phenology, feeding, style and reproductive physiology. *Mam. Rev.* **9(1)**:33-46.

Anderson R.J.F. 1970. The climatic factors in Botswana. *Botswana notes and records.* **2:**75-78.

Andringa, J. 1984. The climate of Botswana in histograms. *Botswana notes and records.* **16:**117-125.

Barnes, R.F.W. 1983. The elephant problem in Ruaha National Park, Tanzania. *Biol. Cons.* **26:**127-148.

Blair-Rains, A. & Mckkay A. 1968. The northern statelands of Botswana. Land resource study No.5.,D.O.S. Tolworth, England.

Burnham, K.P. Anderson, D.R. & Laake J.L. 1980. Estimation of density from line transect sampling of biological populations. *Wildl. mono.* **71:1-102**

Byers, C.R. Steinhorst, R.K. & Krausman, P.R. 1984. Clarification of a technique for analysis of utilisation-availability data. *J. Wild. Mgmt* **48(3):**1050-1053.

Calef, G. W. 1991a. Elephant numbers and distribution in Botswana and northwestern Zimbabwe. In *Proceedings of workshop on Management of the Hwange Ecosystem.* Hwange Safari Lodge 9-13 July, 1991.

Campbell, A.C. 1976. Traditional Utilisation of the Okavango Delta. In: *Proceedings of the symposium on the Okavango Delta and its future utilisation.* Botswana Society, National Museum, Gaborone Botswana.

Caughley, G. 1976. The elephant problem - an alternative hypothesis. *E. Afr. Wildl.J.* **14:**265-283.

Child, G. 1968. An ecological survey of northeastern Botswana. Report to the Government of Botswana. FAO Report No. TA 2563.

Collinson, R.F.H. 1985. Selecting Wildlife Census Techniques, Institute of Natural Resources. University of Natal. Monograph 6.

Cooper, S.M. and N. Owen-Smith. 1987. Assessing the foraging preferences of ungulates by acceptability indices. J. Wildl. Manage. **51(2):**372-378.

Craig, G.C. 1990. Present population and distribution of elephants in northern Botswana. In *The Future of Botswana's Elephants*. ed ,Hancock, P. p16-18 in

Coates Palgrave, K. 1977. *Trees of Southern Africa*. Cape Town, Struik.

Dassmann, R.F. & Mossmann, A.S. 1962. Road strip counts for estimating numbers of african ungulates. *J. Wild. Mgmt.* **26:**101-104.

Dassmann, R.F. & Mossmann, A.S. 1962. Abundance and population structure of wild ungulates. *J. Wild. Mgmt.* **26(3):**262-268.

Dorst, J. & Dandelot, P. 1970. A field guide to the larger mammals of Africa. London. Collins.

du Plessis, S.P. 1969. The past and present geographical distribution of the Perissodactyla and Artiodactyla in southern Africa. MSc. Thesis. University of Pretoria.

Eberhardt, L.L. 1978. Transect method for population studies. *J. Wild. Mgmt.* **42:**1-31.

Ferrar, A.A. and Walker, B.H. (1974). An analysis of herbivore-habitat relationships in Kyle National Park, Rhodesia. *J. Sth. Afr. wild. Mgmt. Assoc.* **4(3):**137-147.

Geist, V. 1971. A behavioural approach to the management of wild ungulates, In: *The scientific management of animal and plant communities for conservation,* ed, Duffey, E. & Watt, A.S. pp 413-424. Oxford. Blackwell.

Gibson, J. 1991. Game-viewing, Tourism. Pages 57-59 in Hancock, P. ed. The Future of Botswana's Elephants, Gaborone, Botswana. 96 pp.

Hahn, H.C.Jr. 1949. A method of censusing deer and its application in the Edwards Plateau of Texas. Unpublished mimeographed report. Texas Game, Fish & Oyster commission.

Henry P.W.T. 1966. Environmental report on the main Chobe forest block. Ministry of Agriculture, Gaborone, Botswana.

Hirst, S.M. 1969. Road strip census techniques for wild ungulates in African woodlands. *J.Wildl.Manage* **33:**40-48.

Jacobsen, N.H.G. 1974. Distribution, Home range and behaviour patterns of bushbuck in the Lutope and Sengwa valleys, Rhodesia. *J. Sth. Afr. Wild. Mgmt. Ass.* **4(2):**75-93.

Lamprey, H.F. et al. 1967.Invasion of the Serengetti National Park by elephant. *E.Afr.Wildl.J.* **5:151-166.**

Levin, R. 1986. In ecology change brings stability. *Science*. November 1986.

Lindsay, W.K. 1990. Elephant/habitat interactions. Pages 19-23 in Hancock, P. ed. The Future of Botswana's Elephants, Gaborone, Botswana. 96 pp.

Melton, D.A. 1985. The status of elephant in Northern Botswana. *Biol. Cons.* **31:**317-333

Mentis, M.T. 1974. Distribution of some wild animals in Natal. Lammergeyer **20:**1-68.

Mitchel, B., Staines, B.W. & Welch, D. 1977. Ecology of Red deer: A research review relevant to their management. Cambridge: Institute of Terrestrial Ecology.

Moroka, D.N. 1984. Elephant - habitat relationships in northern Botswana. Department of Wildlife and National Parks. Gaborone, Botswana. 46pp.

Morris, N.E. 1973. A preliminary investigation of the bushbuck population in the Matsikiti Area, and its relevance to Tsetse control hunting. Msc. thesis, University of Rhodesia.

Norton-Grifiths, M. 1978. Counting Animals. 2nd edition. Nairobi: African Wildlife Leadership Foundation.

Neu, C.W., Byers, C.R. & Peek, J.M. 1974. A technique for analysis of utilisation-availability data. *J. Wildl. Manage.* **38(3)**:541-545.

Odendaal, P.B. 1977. Some aspects of the ecology of the bushbuck (*Tragelaphus scriptus ornatus* Pallas 1776) in the Southern Cape. MSc thesis, University of Stellenbosch, South Africa.

Odendaal, P.B. & Bigalke, R.C. 1979). Home range and groupings of the bushbuck in the southern Cape. *S. Afr. J. Sc.* **9**:96-101.

Odendaal, P.B. 1983. Feeding habits and nutrition of bushbuck in the Knysna forests during winter. *S. Afr. Wildl. Res.* **13**:27-31.

Okiria, R. 1980. Habitat exploitation by the bushbuck in Rwenzori National Park. *Afr. J. Ecol.* **18**:11-17.

Owen-Smith, N. and S.M. Cooper. 1987. Assessing food preferences of ungulates by acceptability indices. J. Wildl. Mgmt. **51(2)**:372-378.

Parry, D. 1989 Draft. Tree canopy cover within the dry season range of elephant in the Chobe National Park, Moremi game reserve and Bokwi island area. *Ecosurv.* February 1991. Kalahari Conservation Society.

Petrides, G.A. 1975. Principal foods versus preferred foods and their relations to stocking rate and range condition. Biol. Cons. **7**:161-169.

Potten, P.H. 1975. Aspects of the recent history of Ngamiland. In: *Investigation of the Okavango as a primary water resource for Botswana.* UNDP/FAO, BOT/71/506, Technical notes **No. 5**. Gaborone, Botswana.

Robinette, W.L. Lovelass, C.M. & Jones, D.A. 1974. Field tests of strip census methods. *J. Wild. Mgmt.* **38(1)**:81-96.

Seber, G.A.F. 1973. The estimation of animal abundance and related parameters. London: Griffin.

Simbotwe, M.P. & Sichone, P.W. 1989. Aspects of behaviour of bushbuck in Kafue National Park, Zambia. *S. Afr.* J. Sc. **19(1)**:38-41.

Simpson, C.D. 1974. Ecology of the Zambezi valley bushbuck (*Tragelaphus scriptus ornatus*) Pocock, 1900. Unpublished Phd dissertation, Texas A & M University, College station, Texas, 274pp.

Simpson, C.D. 1974a. Effects of elephant and other wildlife on vegetation along the Chobe river, Botswana. *Occasional papers, The Museum, Texas Tech. University.* **48**:1-15.

Simpson, C.D. 1974b. Food studies on the Chobe bushbuck (*Tragelaphus scriptus ornatus*) Pocock, 1900. *Arnoldia* **6(32)**:1-9.

Simpson, C.D. 1974c. Habitat preference and seasonal movement in the Chobe bushbuck (*Tragelaphus scriptus ornatus*) Pocock, 1900. *Arnoldia* **6(31)**:1-9.

Simpson, C.D. 1975. A detailed vegetation study on the Chobe River in the northeast Botswana. Kirkia **10(1)**:185-227

Smithers, R.H.N. 1990. The mammals of the Southern African sub-region. Pretoria: University of Pretoria.

Sokal, R.R. and F.J. Rohlf,. 1981. Biometry. W.H. Freeman and Company, New York. 859 pp.

Sommerlatte, M.W. 1976. A survey of elephant populations in north-eastern Botswana. Dept. of Wildlife and National Parks and UNDP/FAO Project 72/020, Wildlife Management and Utilization in Botswana, Gaborone.

Spinage, C.A. 1990. Botswana's problem elephants. Pachyderm **13:**15-19.

Thomas, D.L. and Taylor, E.J. 1990. Study designs and tests for comparing resource use and availability. *J. Wildl. Manage.* **54:**322-330.

Thompson, G.R. 1972. The distribution and habitat preference of bushbuck (*Tragelaphus scriptus ornatus*) within the Victoria Falls National Park. Unpubl. Rept., University of Rhodesia., Salisbury.

Tlou, T. 1976. The peopling of the Okavango Delta -- 1750 - 1906. *Proceedings of the symposium on the Okavango Delta and its future utilisation.* Botswana Society, National Museum, Gaborone Botswana.

Trevor, S. 1992. "Elephant As Architect". *BBC Wildlife magazine Vol.* **10(9):**50-54.

Viljoen, A.J. 1988. Long-term changes in the tree component of the vegetation in the Kruger National Park. Pages 310-315 in Macdonald I.A.W and R.J.M. Crawford eds. Long Term Data Series Relating to Southern Africa's Renewable Natural Resources. South African National Scientific Report **No. 157.**

Waser, P. 1975. Diurnal and nocturnal strategies of the bushbuck (*Tragelaphus scriptus* (Pallas). *E. Afr. Wild. J.* **13:**49-63.

Wilson, V.J. and Child, G. 1964. Notes on bushbuck (*Tragelaphus scriptus*) from a tsetse fly control area in Northern Rhodesia. *Puku* **2:**118-128.

Work, D.R. 1986. Summary report of aerial surveys conducted in 1983, 1984 and 1985. University of the Witwatersrand, Johannesburg. 17pp.

Work, D.R. & Owen-Smith R.N 1986. Preliminary management recommendations for elephant in Northern Botswana. Report for Resource Ecology Group May 1986.

APPENDIX A

A.0 STRIP WIDTH DETERMINATION AND VISIBILITY PROFILES

A.1 INTRODUCTION

The measurement of the strip widths for road strip censuses was required for estimating the area sampled for each vegetation type. This would enable an estimation of the abundance of bushbuck in the intensive study area to be carried out. The lateral visibility (or screening effect) differs in each vegetation type due to the different species composition and physiognomy.

A visibility profile curve was required for each vegetation type to determine the proportion of bushbuck missed during each road count (The Correction Factor) and hence estimate the bushbuck density in the intensive study area.

Various methods of trying to gain an unbiased estimate of the effective strip width have been used in wildlife censuses (Collinson 1985) these include:

(i) Determining the mean sighting distance or Kings method where the distance of all the animals observed is measured at 90° to the transect or road (Burnham et al 1980; Robinette et al 1974).

(ii) The mean visibility method (Hahn 1949; Hirst 1969) where the mean distance at which an object disappears from view is determined.

(iii) Visibility Profile method (Cumming 1975; Lamprey 1964; cited in Collinson 1985; Norton-Griffiths 1978), where the visibility profile is mapped. This method assures that the distance at which animals can be seen varies along the transect.

(iv) Kelkers method (Burnham et al 1980; Robinette et al 1974), where objects seen beyond a certain distance are excluded from the calculation.

(v) Anderson and Pospahala"s method where the proportion of objects missed is determined mathematically (Anderson and Pospahala 1970; Robinette et al 1974).

Norton-Griffiths (1975) found Kings method overestimated the density of animals when compared to standard strip sampling. The disadvantages of the modified strip methods is that they are based on models which are statistically invalid (Burnham et al 1980) except for Anderson and Posphala's method (Collinson 1985).

The aim of the modified strip transect method is to provide a compromise between:
(a) including as many animals as possible in the sample (to improve the estimate of precision) and
(b) reducing the bias resulting from failure to detect all the animals within the sample strip boundary (Caughly 1977).

When it is appropriate to operate from the ground and when animal densities are low and/or visibility is restricted then generally the modified strip sampling methods are preferred to the standard sampling methods (Collinson 1985).

For the purpose of this present study the mean visibility distance was used to determine the strip width. A board of bushbuck dimensions was used to best estimate the distance at which a bushbuck disappears from view. The visibility changes once the rains fall, so the visibility profile was plotted for each vegetation type during the dry months (July - October) and during the wet month (November) once there had been a flush of growth by the vegetation.

A.2 METHODS

A board of approximate bushbuck dimensions (1 m in length by 0.8 m in height) was gridded into 20 equal squares (20cm × 20cm) alternatively painted orange and white. (This facilitated the counting of the squares providing a visual contrast for each square).

Five central points were chosen within each vegetation type. The initial point was chosen by taking a position along the road in each vegetation type (about half way along the length of road that encompassed the particular vegetation type), then walking 50 paces (50 m) into the vegetation, perpendicular to the road. The second point was determined by walking 50 paces from the first and parallel to the road. (Each subsequent point 3 - 5 was 50 paces from the previous point).

The lateral visibility was measured at differing distances from each central point. I chose 4 cardinal directions along the compass bearings 0°, 90°, 180°, 270° to give an overall perspective of the lateral visibility around a point. The board was positioned upright at each central point. I then walked along each compass bearing away from the board and counted the number of squares visible at every 5 m interval until no complete squares were visible. This distance away from the board gave the effective strip width. (A square was recorded if 75% or more of the square was visible).

A total lateral visibility index (LI) was calculated (out of 80) for the radius of 5 m away from the central point by summing the total number of squares seen (out of 20) at 5 m for each compass bearing. This was repeated for the 10, 15, 20 and 25 m distances from the centre.

A visibility profile was constructed for each vegetation type by plotting the lateral visibility indices against distance for the dry (measured in August) and wet (measured in November) months (Figs 3A - 3E). These visibility profiles were used for estimating the percentage of bushbuck missed during each road count.

A.3 CORRECTION FACTOR

Using the visibility profiles constructed for each vegetation type a correction factor (CF) was calculated. This (CF) was required to determine an estimation of the population density within the ISA.

An arbitrary cut off point of lateral visibility 16 was chosen since this represents 20 % of a bushbuck. This cut off criteria declares that when 20 % or more of a bushbuck is visible there is a 100 % chance that it will be observed during the censuses. This method is quite subjective, however from field observations I felt it was a conservative approximation to assume the above criteria.

The percentage of bushbuck missed during each count was estimated using the visibility profiles in each vegetation type for both the wet and dry season months. From the profile a horizontal line was drawn at the lateral visibility index 16 and a vertical line was drawn at 25 metres (size of the strip width). The total area enclosed by these boundaries was calculated (T). The area above the visibility profile (dry or wet season), but within the total area was estimated (shown as the shaded area in fig A1). The percentage of this area out of the total area represented the correction factor (CF) for each count. A correction factor was estimated for both the dry and wet season months for each vegetation type.

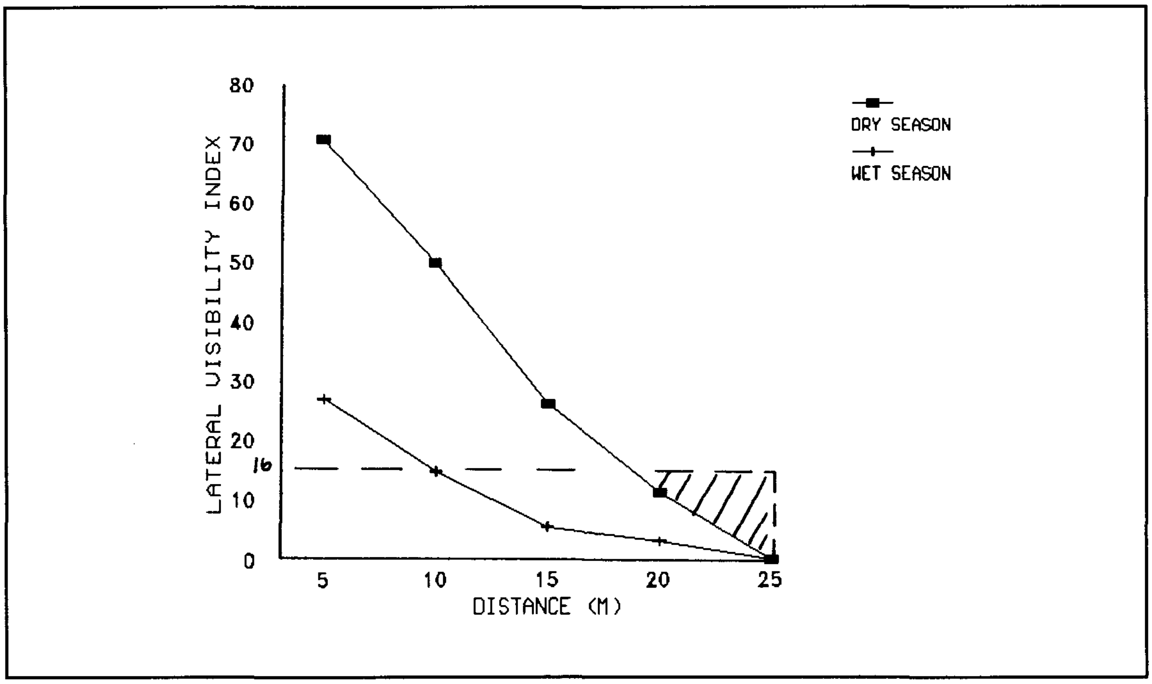

Figure A1: Lateral visibility indices recorded in the riparian fringe woodland during the dry and wet seasons

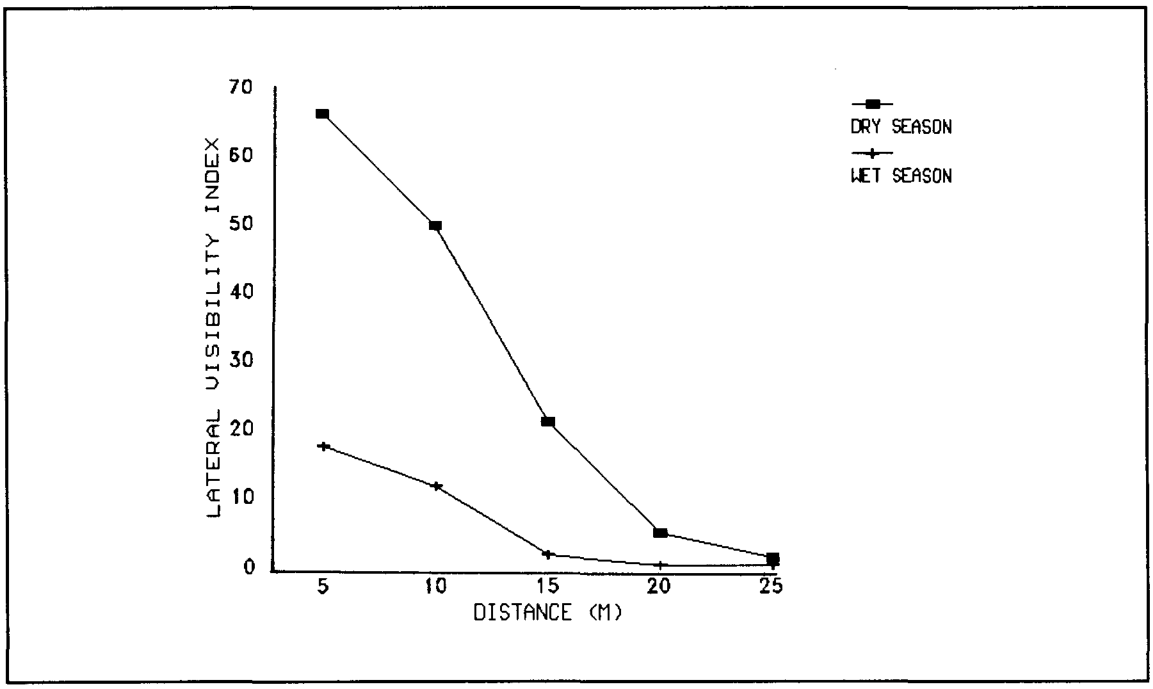

Figure A2: Lateral visibility indices recorded for the *Croton-Capparis* shrubland during the dry and wet seasons

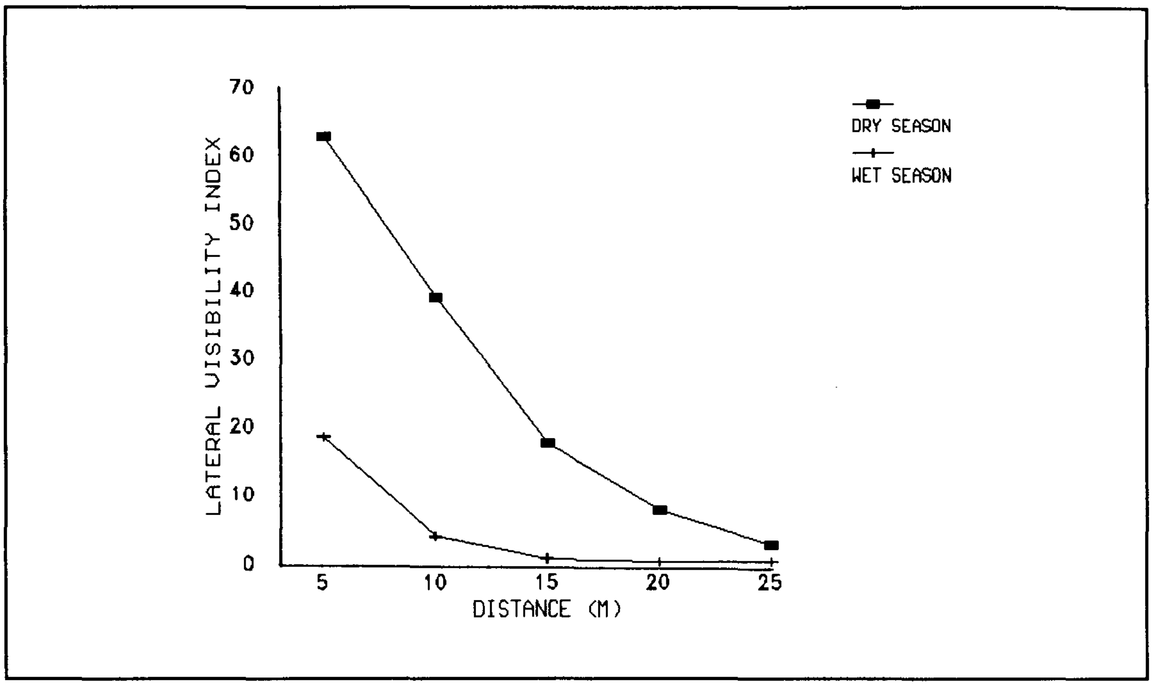

Figure A3: Lateral visibility indices recorded in the *Combretum-Baphia* shrubland during the dry and wet seasons

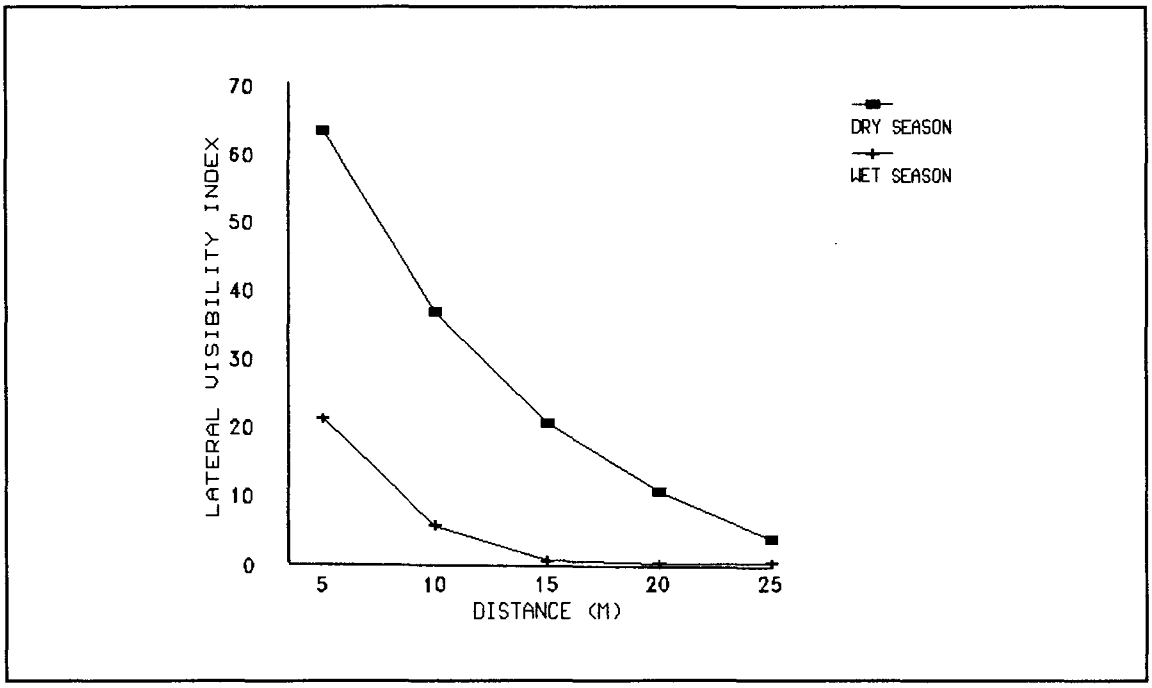

Figure A4: Lateral visibility indices recorded in the *Acacia* woodland during the dry and wet seasons

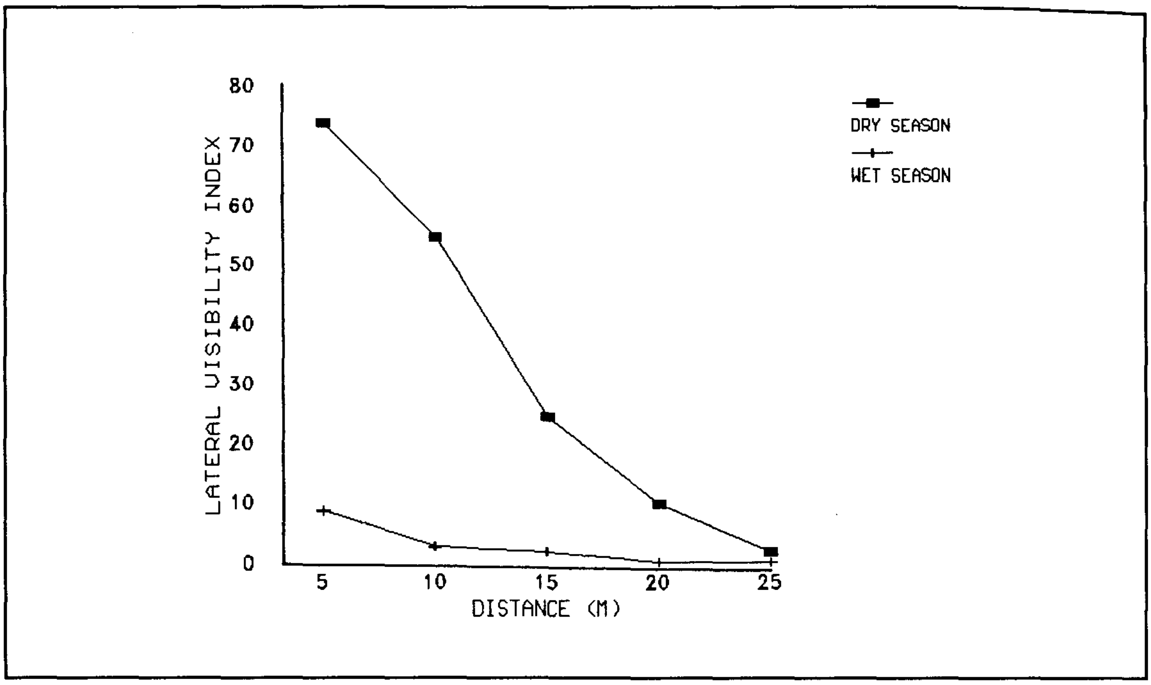

Figure A5: Lateral visibility indices recorded in the *Combretum-Dichrostachys* thicket during the dry and wet seasons

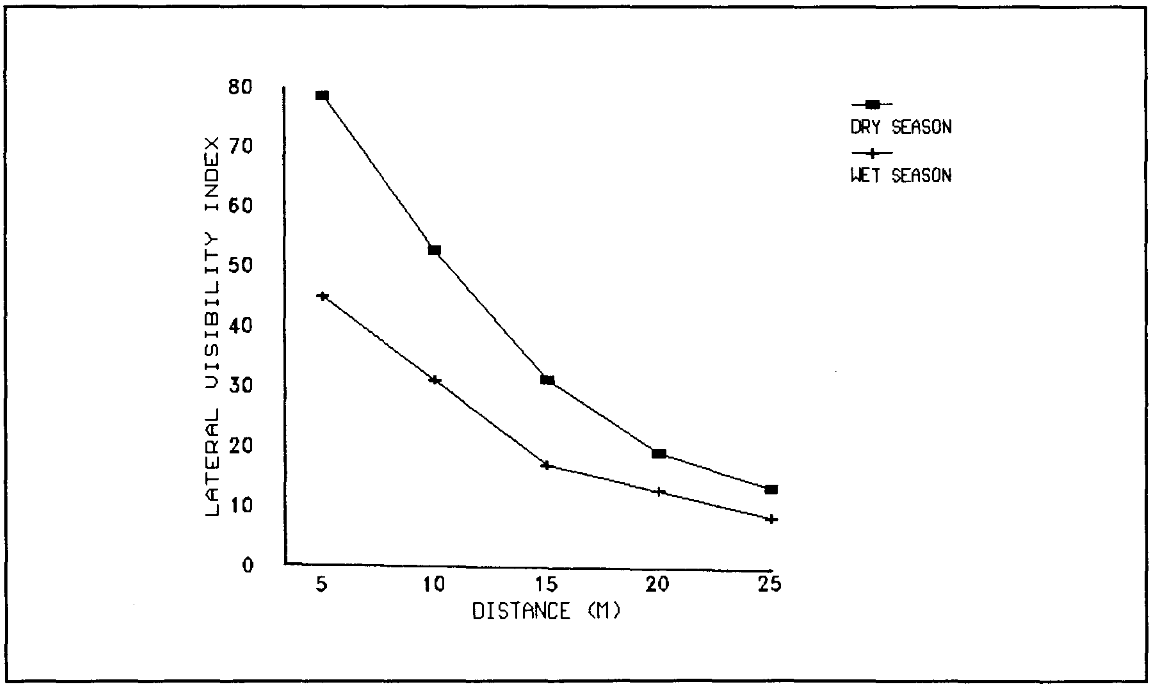

Figure A6: Lateral visibility indices recorded in the mixed ecotone during the dry and wet seasons

The corrected number of bushbuck was estimated for each vegetation type during each count using the following procedure:

Correction factor per count in a certain veg type = {CF $\times$ count total} + count total

Table A(i) illustrates the correction procedure used for a single count undertaken in July.

Table A (i) Example of calculating the corrected number of bushbuck per count in the different vegetation types.

VEGETATION TYPE	NUMBER BUSHBUCK SEEN	CORRECTION FACTOR USED	CORRECTED NUMBER
RIPARIAN FRINGE WOODLAND	1	0.136	1.14
CROTON-CAPPARIS SHRUBLAND	1	0.211	1.21
COMBRETUM-BAPHIA SHRUBLAND	3	0.184	4.18
ACACIA WOODLAND	0	0.131	0.13
COMBRETUM-DICHROSTACHYS THICKET	0	0.165	0.17
MIXED ECOTONE	0	0.140	0.14
TOTALS	5		6.97

A.4 RESULTS

The lateral visibility profiles clearly illustrate the differences in the visibility for the dry and wet seasons. (Fig A1-A6). A high lateral visibility index represents a high visibility but a low screening effect of the vegetation, (ie; a greater number of squares on the board are visible).

(1) STRIP WIDTHS.

Table A(ii) shows the strip widths used for the dry and wet season months. For all the vegetation types in the dry season months (July through October) the maximum strip width was 25 metres on either side of the road. However in the wet season the maximum strip widths were less than 25 m in the *Combretum-Baphia shrubland, Combretum-Dichrostachys* thicket and *Acacia* woodland vegetation types.

(2) CORRECTION FACTORS

The correction factors were calculated for the dry and wet months for each vegetation type within the ISA and are illustrated in Table A(iii). The correction factors are considerably higher for November (the wet month) compared to the dry months (July through October).

Table a(ii): Values used for calculating the average area sampled in each vegetation type during the road counts within the intensive study area

VEGETATION TYPES	ROAD LENGTH (m)	STRIP WIDTH (m) DRY SEASON	STRIP WIDTH (m) WET SEASON	AREA SAMPLED (m^2) DRY SEASON	AREA SAMPLED (m^2) WET SEASON
RIPARIAN FRINGE WOODLAND	600	25	25	15000	15000
CROTON-CAPPARIS SHRUBLAND	1170	25 × 2	20 × 2	58500	46800
COMBRETUM-BAPHIA SHRUBLAND	1420	25 × 2	18 × 2	71000	51120
ACACIA WOODLAND	3330	25 × 2	18 × 2	166500	119880
COMBRETUM-DICHROSTACHYS THICKET	500	25 × 2	20 × 2	25000	20000
MIXED ECOTONE	100	25 × 2	25 × 2	5000	5000
TOTAL (m^2)				341000	257800
TOTAL (km^2)				0.341	0.2578
TOTAL (ha)				34.1	25.78

Table A(iii): Correction factors used for each vegetation type

VEGETATION TYPES	DRY SEASON	WET SEASON
RIPARIAN FRINGE WOODLAND	0.136	0.447
CROTON-CAPPARIS SHRUBLAND	0.211	0.415
COMBRETUM-BAPHIA SHRUBLAND	0.184	0.582
ACACIA WOODLAND	0.131	0.448
MIXED ECOTONE	0.140	0.108

The corrected number of bushbuck seen in each vegetation type was estimated for each count and Table A(iv) represents the monthly corrected totals. The correction factors were greatest in the November, as the lateral visibility is somewhat reduced by the growth of the plants once the rains have fallen.

Table A(iv) Number of bushbuck seen during ISA road counts, determined using the correction factors for each vegetation type. Actual bushbuck counted expressed in parenthesis.

MONTH	NUMBER OF COUNTS	NUMBER OF BUSHBUCK SEEN USING CORECTION FACTOR (UNCORRECTED NUMBERS IN PARENTHESIS)						TOTAL NUMBER
		RIPARIAN FRINGE WOODLAND	*CROTON-CAPPARIS* SHRUBLAND	*COMBRETUM-BAPHIA* SHRUBLAND	*ACACIA* WOODLAND	*COMBRETUM-DICHROSTACHYS* THICKET	MIXED ECOTONE	
JULY	11	10 (9)	12 (11)	7 (6)	3 (3)	1 (1)	0 (0)	33 (30)
AUGUST	18	20 (18)	30 (30)	3 (3)	12 (12)	2 (2)	0 (0)	67 (65)
SEPTEMBER	21	12 (12)	25 (22)	8 (8)	8 (8)	1 (1)	0 (0)	54 (51)
OCTOBER	21	7 (7)	9 (8)	28 (25)	11 (11)	2 (2)	0 (0)	57 (53)
NOVEMBER	21	7 (5)	11 (6)	34 (21)	32 (23)	2 (1)	2 (2)	87 (58)
TOTAL	97	56 (51)	87 (77)	80 (63)	66 (57)	8 (7)	2 (2)	298 (257)

APPENDIX B

The details of the exact location of the four belt transects which extended from the rivers edge to the southern boundary of the intensive study area are as follows:

(a) Transect 1 - Crocodile island transect.

Crocodile island transect was located in the eastern end of the ISA. This transect crossed the road to the Chobe game lodge at 500 m east of the SSP. An already established cement block (which indicates the position of underground power lines) with 11 KV inscribed on it was used as a permanent marker for this transect. The 2 m wide belt transect extended north from this marker to the river along the north-south compass bearing. This transect terminated at the rivers edge opposite "Crocodile island". The transect extended south through the ISA to the tourist road (Fig 3.2) in the *Baikaea* woodland.

(b) Transect 2 - Nantanga loop transect.

This transect was located 100 m east of the Nankanga loop turn off. The south eastern corner of the memorial plaque for the first park game warden was used as the permanent marker for this transect. The transect extended north to the river from the plaque along the north-south compass bearing. The transect extended southwards from the permanent marker through the ISA, crossed the road 2.1 km from the SSP and stopped on reaching a line of *Loncocarpus capassa* trees (Fig 3.2).

(c) <u>Transect 3 - Bushbuck drive transect.</u>

This third transect was located along "Bushbuck drive" tourist road, 3.2 km west of the SSP. From this point the transect extended northwards to the rivers edge along the north-south compass bearing. The transect continued southwards along this 0° bearing through the ISA until it reached the "Bushbuck drive" entrance road (Fig 3.2).

(d) <u>Transect 4 - Rhino pens transect.</u>

The final transect through the ISA was located in the western end of the ISA, 4.4 km west from the SSP and 50 m east of "Rhino pens"). The transect followed the 0° compass bearing north to the rivers edge. This transect extended south through the ISA, crossed "Bushbuck drive" exit road (500 m from the river end of this road) and continued towards the main Kasane-Serondella road (Fig 2.2).

APPENDIX C

An example of how to construct the Bonferonni *z* statistic family confidence coefficient and associated tables for the chi-square statistics. (After Neu et Al 1974).

Table i: Sightings of bushbuck in 6 vegetation types over the 5 month study period.

VEGETATION TYPE	AREA SAMPLED (HA)	EXPECTED PROPORTION USEAGE	NUMBER OF BUSHBUCK SIGHTINGS	EXPECTED NUMBER OF BUSHBUCK SIGHTINGS	OBSERVED PROPORTION USEAGE	X^2 VALUE	95% FAMILY CONFIDENCE COEFFICIENTS
RIPARIAN FOREST FRINGE	1.50	0.044	34	8	0.1899 *+ve	84.50	$0.112 \leq p \leq 0.266$
CROTON-CAPPARIS SHRUBLAND	5.85	0.172	56	31	0.3128 *+ve	20.16	$0.211 \leq p \leq 0.404$
COMBRETUM-BAPHIA SHRUBLAND	7.10	0.208	49	37	0.2569	2.19	$0.171 \leq p \leq 0.343$
ACACIA WOODLAND	16.65	0.488	36	87	0.2011 *-ve	29.89	$0.122 \leq p \leq 0.280$
COMBRETUM-DICHROSTACHYS THICKET	2.50	0.073	6	13	0.0335 *-ve	3.78	$-0.003 \leq p \leq 0.070$
MIXED ECOTONE	0.50	0.015	1	3	0.0056	1.33	$-0.009 \leq p \leq 0.021$
TOTALS	34.10	1.000	179	179	0.999	141.85	

(X^2 = 141.85 df = 5, P < 0.001)

* indicates the vegetation types where expected and observed values are significantly different.

1 Proportion of total acreage represents expected animal observation values as if animals occurred in each habitat in exact proportion to availability. (Expected proportion of useage; p_{ie})

i.e., 1.5/34.1 = 0.044

2 Calculated by multiplying proportion (pi_e) × N; i.e.,

0.044 × 182 = 8.01

3 Calculated by dividing number observed by total number.

i.e., 34/182 = 0.1868

4 Bonferonni confidence intervals were calculated using the following formula:

$$p_{io} - Z_{\alpha/2k} \sqrt{p_i(1 - p_i)/N} \leq p_i \leq p_{io} + Z_{\alpha/2k} \sqrt{p_i (1 - p_i)/N}$$

where: p_{io} is the observed actual proportion of useage.

$Z_{\alpha/2k}$ is the upper standard normal value corresponding to a probability tail area of $\alpha/2k$; k is the number of categories (vegetation types).

Therefore $\alpha = 0.05$; $k = 6$; $Z_{\alpha/2k} = 2.640$ (obtained fro the table of normal distribution).

i.e.,For RFF vegetation type the 90% confidence coefficient is:

$$0.1868-2.640\{\sqrt{0.1868(1-0.1868)/182}\} \leq p_i \leq 0.1868+2.640\{\sqrt{0.1868(1 - 0.1868)/182}\}$$

$$\mathbf{0.110 \leq p_i \leq 0.262}$$

If the value of the Expected proportion of useage (pi_e) does not fall within the confidence intervals we conclude that the Expected and the Observed utilisation are significantly different.

From Table i, animals occurred in vegetation types RFF and C-B more than expected and in vegetation type ME less than expected according to the Bonferonni *z* statistic.